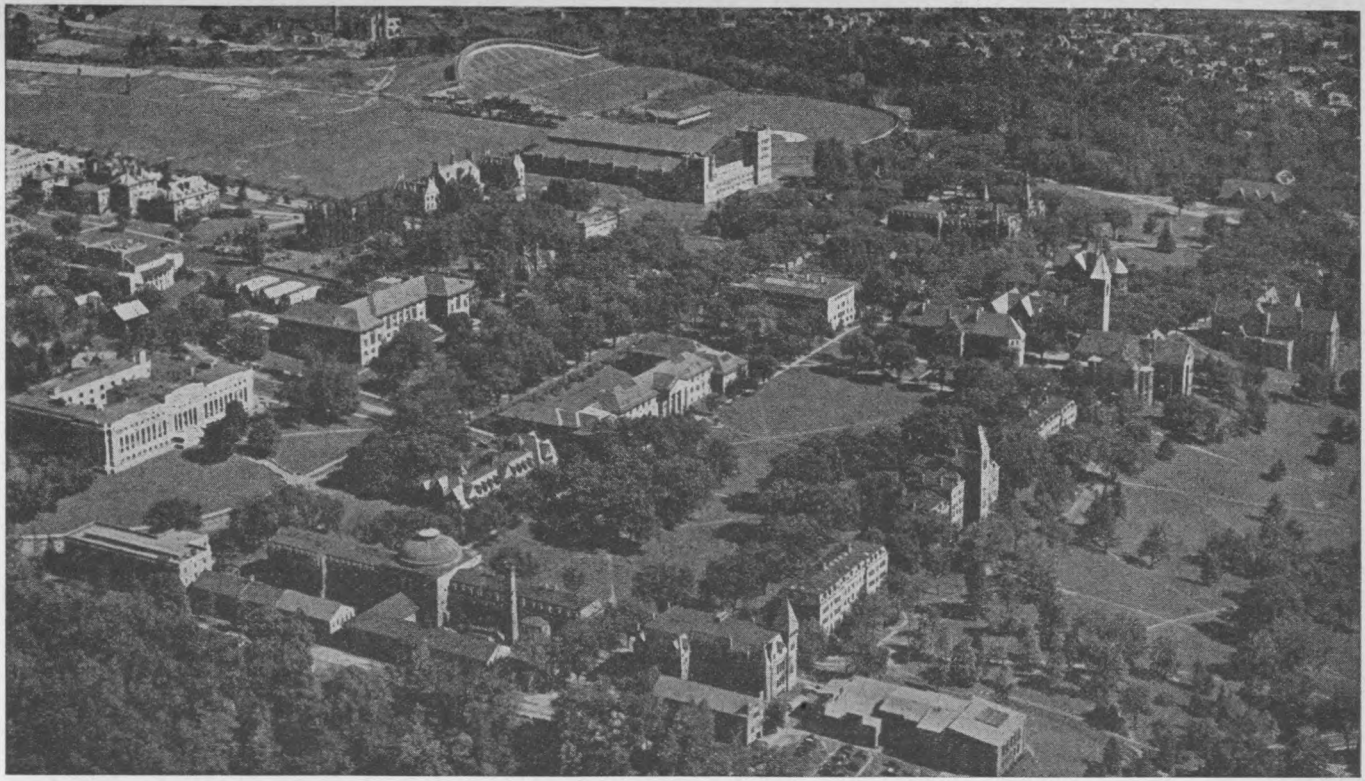

THE MAIN QUADRANGLE AND SOME OF THE OTHER PRINCIPAL BUILDINGS OF CORNELL UNIVERSITY

In the foreground and left center are the Engineering group and the laboratories of Chemistry and Physics. In the background are the playgrounds and football and baseball fields. The camera has missed the men's dormitories and other buildings on the right and a large part of the campus on the left. Also the picture does not show the recently completed Olin Hall of Chemical Engineering, one of the largest buildings on the campus.

*Announcement of the*

# College of Engineering

*including*

THE SCHOOL OF CIVIL ENGINEERING

THE SIBLEY SCHOOL OF MECHANICAL ENGINEERING

THE SCHOOL OF ELECTRICAL ENGINEERING

THE SCHOOL OF CHEMICAL ENGINEERING

THE COURSES IN ADMINISTRATIVE ENGINEERING


1944-45

# The University Calendar for 1944-45

*Under the accelerated program of instruction, the University will offer three terms of sixteen weeks each during the course of the year 1944–45, as follows:*

| *1944* | | SUMMER TERM |
|---|---|---|
| June 30, | *Friday,* | Registration, civilian students. |
| July 1, | *Saturday,* | Registration, Navy students. |
| July 3, | *Monday,* | Instruction begins. |
| Oct. 21, | *Saturday,* | Term ends. |
| | | FALL TERM |
| Oct. 31, | *Tuesday,* | Registration, civilian students. |
| Nov. 1, | *Wednesday,* | Registration, Navy students. |
| Nov. 2, | *Thursday,* | Instruction begins. |
| Dec. 21–27, | *Thurs.-Wed.,* | Christmas Recess. |
| *1945* | | |
| Feb. 28, | *Wednesday,* | Term ends. |
| | | SPRING TERM |
| March 2, | *Friday,* | Registration, civilian students. |
| March 3, | *Saturday,* | Registration, Navy students. |
| March 5, | *Monday,* | Instruction begins. |
| June 23, | *Saturday,* | Term ends. |

CORNELL UNIVERSITY OFFICIAL PUBLICATION

PUBLISHED BY CORNELL UNIVERSITY AT ITHACA, N. Y.

Monthly in September, October, and November
Semi-monthly, December to August inclusive

[*Entered as second-class matter, December 14, 1916, at the post office at Ithaca, New York, under the act of August 24, 1912*]

# Contents

## SPECIAL ANNOUNCEMENT

Cornell University has been designated as one of the institutions to give the United States Navy's specialized training program, V-12. This program includes 8-term curricula in civil, mechanical, and electrical engineering, which, when completed, lead to the special degree of Bachelor of Science in these branches.

The main efforts in the several Schools will be directed toward the training of Naval and Marine students. Adequate provision, however, for continued training of civilian students has been made in all basic curricula. This publication is devoted solely to these civilian curricula which lead to the usual Bachelor degrees.

Wherever possible, the courses in the Navy program have been adopted for civilian students as well. Naval, Marine, and civilian students will attend classes together in such courses.

The University is operating on a war basis, with instruction continuing throughout the calendar year. In the College of Engineering, three terms of 16 weeks each are completed each year. This acceleration is compulsory and enables the student to complete the normal 4-year course in 2⅔ years. Terms will begin about March 1, July 1, and November 1.

# The College of Engineering

## ITS HISTORY AND ORGANIZATION

Engineering has had an important place in the program of Cornell University from the beginning. The Federal Land Grant, or Morrill Act of 1862, which supplied a considerable proportion of the University's original endowment, specified that a leading object of the institution should be to teach "such branches of learning as are related to . . . the mechanic arts"; and this provision was in perfect accord with the ideals of the founder and of the first president. Both Ezra Cornell, the practical man of affairs, who had amassed a fortune in the Western Union Telegraph Company, and Andrew D. White, the brilliant scholar and educator, who had carefully analyzed contemporary higher education in America and in Europe, believed in the equal dignity of scientific and classical studies and determined to put the practical arts, such as engineering, on the same plane with the humanities. This program was considered revolutionary when announced at the University's opening in 1868. That it has since been generally adopted by American universities indicates the soundness of the basic Cornell idea that instruction in engineering should be given on a high professional level. The College of Engineering still adheres firmly to this policy.

Mechanical engineering and civil engineering have been strong divisions of the University since its foundation. The first was originally called the College of Mechanic Arts and later the Sibley College of Mechanical Engineering and Mechanic Arts, in recognition of munificent gifts by Hiram Sibley, founder of the Western Union Telegraph Company, and his son, Hiram W. Sibley. Civil Engineering, originally a separate school in the College of Mathematics and Engineering, and later the College of Civil Engineering, has also retained its identity to the present day.

In 1883 Cornell opened courses in electrical engineering, among the first to be offered anywhere in America; and in 1919, when the Board of Trustees formed the present College of Engineering, the School of Electrical Engineering was established as one of the three component units, on a par with the Sibley School of Mechanical Engineering and the School of Civil Engineering.

The College of Engineering organized a five-year course in Chemical Engineering in 1931; and seven years later the School of Chemical Engineering was established to supervise the curriculum which leads to the degree of Bachelor of Chemical Engineering. Four-year courses leading to the degree of Bachelor of Science in Administrative Engineering in civil, mechanical, and electrical engineering were introduced in 1931.

Students in Engineering at Cornell use the facilities of the several Sibley buildings which house the Sibley School of Mechanical Engineering; Lincoln Hall which is devoted to the School of Civil Engineering; Franklin Hall which contains most of the School of Electrical Engineering; Rand Hall, the gift of Mrs. Florence O. R. Lang, in which are located the Machine Shop, Pattern Shop, and senior Electrical Laboratory; the Hydraulic Laboratory on Beebe Lake above Triphammer Falls; and Olin Hall of

Chemical Engineering, recently given by Franklin W. Olin to provide most adequately for the School of Chemical Engineering. For various preparatory and elective courses they also use the facilities of the Baker Laboratory of Chemistry, a building given to the University in 1922 by George F. Baker; and those of Rockefeller Hall, erected by John D. Rockefeller for the Department of Physics; and other buildings and equipment available in the College of Arts and Sciences.

Cornell engineers enjoy all the benefits and privileges of an outstanding university community. They associate continually, in fraternities and dormitories, in extra-curricular activities, and in general University functions, with students of liberal arts, agriculture, law, veterinary medicine, and architecture. Concerts by world-famous soloists and orchestras, lectures by renowned scholars in widely varying fields, dramatic productions, and art exhibits add to the cultural atmosphere in which Cornell engineers move as undergraduates.

These facts, in addition to the beauty of the Campus and the surrounding Finger Lakes region and the consideration that Ithaca is a small city, removed from the distractions of a metropolitan area but easily accessible by railroad and highway, help to explain the composition of the student population, which each year includes students from every part of the United States and numerous foreign countries.

The College of Engineering now comprises the School of Civil Engineering, the Sibley School of Mechanical Engineering, the School of Electrical Engineering, and the School of Chemical Engineering. Courses in Administrative Engineering are given in the first three of these Schools. Graduate instruction in engineering is offered by the Engineering Division of the Graduate School of the University.

## PURPOSE OF THE INSTRUCTION

Engineering education at Cornell is broadly professional, designed to train men for leadership in public service, business, and industry. In the opinion of the Faculty, confirmed by representatives of concerns employing the bulk of engineering graduates, technical competence in the general field of engineering is essential to success even in the narrower specializations, such as radio, aeronautics, and air-conditioning, and time spent on fundamentals shortens the period of adjustment during which the graduate engineer discovers the speciality he is best fitted to pursue. Hence the College emphasizes instruction in the basic principles and applications of science, and offers specialized options only to a limited extent.

Experience has demonstrated that the secondary school student often lacks the ability to anticipate with accuracy the type of work for which he will ultimately find himself best adapted. Some of the largest industries, which offer the widest variety of opportunity within their own organizations, consider it necessary to observe even the engineering graduate for at least a year before deciding to what division of the company he should be assigned. Their records contain many instances of men who originally desired to become air-conditioning experts or airplane designers but eventually applied their personal aptitudes most successfully in such fields as power-plant management or metallurgical research.

Furthermore, a successful career is a record of competence in a series of situations actually available. No student can be certain that he will be offered precisely the employment that he desires at the time he graduates. Nor, in these times of rapid advances in technology, can he be sure that such a situation, if offered, would be a step along the road to the highest achievement of which he is capable. In electrical engineering, for instance, the full effect of the vacuum tube is as yet unknown, but this invention has already required not only a modification of existing electrical machines, but also an entirely new theoretical approach. Similar developments have taken place and will continue in the fields of mechanical, civil, and chemical engineering. Like the village blacksmith, the narrow specialist in engineering may one day find his specialty no longer in demand. Only a broad and intensive training in the fundamental sciences can fit an engineer to take advantage of new opportunities as progress in industry creates them.

Just as the modern engineer needs broad and deep scientific training, he also must have a working knowledge of the social and economic structure. He can no longer act as an isolated technician; he must become an effective part of the society in which he lives, able to see the results of his efforts in relation to the industrial and social system as a whole. Unemployment, the standard of living, mass prejudices, political programs—all affect him not only as a person but also as an engineer. Such factors have constantly increasing significance in any program of public works or industrial development, and the engineer must understand them in order to solve his professional problems.

These considerations explain certain general features of the courses of study offered by the College. In all the schools, specialization has been postponed until late in the course and is limited both in character and in extent; and opportunities have been made for required and elective courses in such fields as physical science, social studies, and written and spoken English.

Dominant in all the courses of study is instruction designed to teach the fundamental principles, theoretical and practical, that underlie the various branches of engineering. Classroom instruction and laboratory experiment are supplemented by experience with the operation of various kinds of apparatus in the College laboratories and shops and by trips to inspect manufacturing plants, public works, and other places of interest in the industrial centers of the East. The student thus becomes familiar with problems encountered in modern engineering and with practical methods for their solution.

The basic purpose of the entire program is to make adjustment easier for the graduate when he begins actual engineering work, and to fit him for leadership in his profession.

DEGREES OFFERED Cornell University confers the following degrees on the successful completion of undergraduate courses of study in the College of Engineering: Bachelor of Science in Civil Engineering (B.S. in C.E.); Bachelor of Civil Engineering (B.C.E.), Bachelor of Science in Mechanical Engineering (B.S. in M.E.), Bachelor of Mechanical Engineering (B.M.E.), Bachelor of Science in Electrical Engineering (B.S. in E.E.), Bachelor of Electrical Engineering (B.E.E.), Bachelor of Science in Administrative Engineering (B.S. in A.E.), and

Bachelor of Chemical Engineering (B. Chem. E.), Bachelor of Science in Chemical Engineering (B.S. in Chem.E.). The Bachelor of Science degrees, except those in Administrative Engineering and Chemical Engineering, are primarily for Naval and Marine students who complete the V-12 program prescribed by the Navy.

The advanced degrees of Master of Chemical Engineering (M. Chem.E.), Master of Civil Engineering (M.C.E.), Master of Electrical Engineering (M.E.E.), Master of Mechanical Engineering (M.M.E.), Master of Science in Engineering (M.S. in Engineering), Master of Science (M.S.), and Doctor of Philosophy (Ph.D.) are granted by the University on the recommendation of the Faculty of the Graduate School. (See page 12).

EIGHT-TERM CURRICULA

The eight-term curricula offered in the College lead to the degree of B.C.E., B.M.E., B.E.E., B.S. in A.E. and B.S. in Chem.E. respectively. Later in this Announcement there will be found, under the appropriate heads, detailed statements of these curricula. In the last two terms of each curriculum, certain options or electives are offered, so that each student may have a certain amount of freedom in placing the main emphasis of his work upon branches of the profession in which he may be most interested. These options and the elective courses are clearly defined in the announcement of each school on subsequent pages.

TEN-TERM CURRICULA

The normal curriculum of study leading to the degree of Bachelor of Chemical Engineering consists of an integrated ten-term program in which provision is made for a considerable amount of elective work. For the duration of the war, this curriculum has been abbreviated to eight terms, leading to the degree of Bachelor of Science in Chemical Engineering. The ten-term curriculum will be restored as soon as circumstances permit.

Ten-term curricula leading to the single degree of B.C.E., B.M.E., B.E.E., or B.S. in A.E. consist of the eight-term engineering courses of study modified by the introduction of the equivalent of two terms of broadening training. The entrance requirements are those of the eight-term curricula.

It is possible to rearrange the required work in the respective eight-term curricula of study in mechanical and electrical engineering so that both the B.M.E. and B.E.E. degrees may be obtained in a ten-term period of study.

In administrative engineering it is possible so to arrange the work of the ten-term curriculum that the degree of B.C.E., B.M.E. or B.E.E. is obtained at the end of the first eight terms and the degree of Bachelor of Science in Administrative Engineering at the end of the last two terms. Declaration of intention to take ten-term combinations should be made before the beginning of the student's third term.

TWELVE-TERM CURRICULA

The twelve-term curricula leading to the degrees of A.B. and B.C.E., or A.B. and B.M.E., or A.B. and B.E.E., or A.B. and B.S. in A.E., require admission to the College of Arts and Sciences, in which college the student is registered during the first

eight terms. In order to make it possible to obtain the B.C.E., B.M.E., B.E.E., or B.S. in A.E. degree at the end of the twelfth term, the student must complete the freshman engineering subjects before the beginning of his seventh term, and must complete the list of sophomore subjects in civil engineering, mechanical engineering, or electrical engineering before the beginning of his ninth term. Advice and assistance in arranging such a course may be obtained by applying to the director of the school concerned.

### SCHOLASTIC REQUIREMENTS

In the Schools of Civil, Electrical, and Mechanical Engineering a student who does not receive a passing grade in every course in which he is registered, or who fails, in any term or summer session, to maintain an average of 65 per cent or better, with at least half the credit hours with marks of 70 per cent or better, may be dropped from the University, or placed on probation.

A student in the School of Chemical Engineering who does not receive a passing grade in every course for which he is registered, or who fails in any term or summer session to maintain an average grade of 75 per cent may be dropped or placed on probation.

If in the opinion of the Faculty of the School concerned, a student's general record is unsatisfactory, the student may be refused permission to continue his course even though he has met the minimum requirements in respect to the number of hours of work passed and the grades in those hours. Students who fall behind in their work may be warned, put on probation, or dropped, either from an individual course, or from the University at any time during the term.

### THE REQUIREMENTS FOR GRADUATION

Degrees are conferred on candidates who have fulfilled the following requirements:

1. The candidate must have been in residence and registered in the College of Engineering for the last two terms and must have satisfied the University requirements in Military Science and Tactics (or Physical Education), Physical Training, and in the payment of tuition and fees.

2. He must have completed to the satisfaction of the Faculty of the College of Engineering all the subjects, and the elective hours, prescribed in the course of study as outlined by that faculty.

3. A student who transfers to the College of Engineering, after having spent one or more terms in another college of Cornell University or elsewhere, must conform to the requirements of the class with which he graduates.

### UNIVERSITY REQUIREMENTS

#### MILITARY SCIENCE

Cornell University requires men of the Freshman and Sophomore classes to take the Basic Course in Military Science and Tactics. That requirement is precisely defined, and exceptions and alternatives are clearly stated, in the *General Information Number*, which should be consulted. See also page 115 of this Announcement.

PHYSICAL TRAINING

All undergraduate men, unless officially excused, are required to follow a program of physical training, for the satisfactory completion of which one hour of credit a term will be allowed.

All undergraduate women, unless officially excused, are required to follow a program of physical education during the first four terms of their course of study. For the satisfactory completion of this requirement one hour of credit a term will be allowed.

These requirements are administered by the Dean of the University Faculty, 201 Morrill Hall.

REQUIREMENTS CHANGEABLE The College of Engineering reserves the right to modify its curricula and specific courses of instruction, to alter the requirements for admission or for graduation, and to change the degrees to be awarded, and such changes are applicable to either prospective or matriculated students at any such time as the college may determine.

GRADUATE STUDIES Graduates of this College or of other colleges of engineering may enter the Graduate School of Cornell University and pursue advanced work in engineering. Such a student may enter either as a candidate for a degree (M.C.E., M.M.E., M.E.E., M.Chem.E., M.S. in Engineering, M.S., or Ph.D.) or without candidacy for a degree, according to the character of his previous training. A prospective graduate student should consult the *Announcement of the Graduate School* and apply to the Dean of the Graduate School. Information concerning graduate scholarships and fellowships, including the John McMullen Graduate Scholarships, can be obtained either from the Dean of the Graduate School or from the Dean of the College of Engineering.

PERSONNEL AND EMPLOYMENT PROGRAM The College of Engineering maintains a Personnel and Employment Office under the direction of the College Personnel Officer. In cooperation with this office, each school has a personnel adviser to work with the student in an appraisal of his personal characteristics and to assist him in deciding upon the type of work for which he is best suited.

Beginning with the Class of 1928, periodic surveys have been made of all graduates and a detailed record is kept of their activities since graduation. Information thus assembled is used in determining industrial and occupational trends. In cooperation with the University Placement Service, employment information is sent to those graduates who request it.

THE ENGINEERING COLLEGE COUNCIL The Engineering College Council consists of the President of the University, the Dean of the College, and a group of distinguished engineers, usually alumni, approved by the Board of Trustees of the University. The duties of the Council are to become thoroughly acquainted with the affairs of the College, to advise the administration and the Board of Trustees with regard to policies and

programs designed to increase the efficiency of the established operations, to add to the available resources, to improve public and alumni relations, or in any other way to strengthen the College's work.

## MISCELLANEOUS INFORMATION

*Dean's Honor List.* Students of the College of Engineering whose weighted average in their studies is 85 per cent or better are included annually in an Honor List compiled for the Dean, who makes a public announcement of the names of those students at an event known as "Honor Night" which the College holds in the spring of each year. The honor students comprise approximately the highest tenth of all the students enrolled in the college.

*Student Activities.* Students of the College of Engineering find many opportunities of engaging in wholesome activities outside their regular duties, and even outside the College, in company with members of the University generally. Within the College some find congenial occupation in helping to carry on the student branches of the national engineering societies, in conducting *The Cornell Engineer*, or in membership in national or local honor societies, which include Tau Beta Pi, Phi Kappa Phi, Sigma Xi, Chi Epsilon, Rod and Bob, Pyramid, Atmos, Kappa Tau Chi, and Eta Kappa Nu. In the University at large there are student activities of all sorts, musical, dramatic, journalistic, social, and athletic.

*Engineering Societies.* The College of Engineering is closely associated with the Ithaca Sections of the American Society of Civil Engineers, American Society of Mechanical Engineers, and American Institute of Electrical Engineers, many of the meetings of which are held on the campus and are participated in by the members of the College. The College also maintains active student branches of these national societies as well as of the American Institute of Chemical Engineers. Their meetings are addressed by engineers of eminence, or are used for the presentation of papers by students, or for discussion, or for contests in public speaking on engineering subjects. The Schools of Mechanical and Electrical Engineering give elective credit hours for activity in the student branches of their respective engineering societies.

*The Cornell Engineer*, a technical journal published monthly throughout the academic year, is managed and edited by undergraduates in the College of Engineering. Elective credit is given for work on this magazine. (See page 114.)

*Student Counselors.* In each of the Schools the students have the assistance of a special corps of Class Advisers in the planning and scheduling of their academic work. Also the students are free to consult with the Dean, Directors, Department Heads, and the Instructors not only on matters pertinent to their education and future plans, but also on personal matters. In addition, the University's Counselor of Students for men and his staff may be consulted by men students regarding their non-academic problems. There is also a Counselor of Students for women.

*Assistance to Foreign Students.* The University maintains on its staff a Counselor to Foreign Students, whose duty is to look after the welfare of all students from other countries. He may be consulted on personal prob-

lems, social questions, or any other matter in which he may be helpful. His office is in the Cornell Cosmopolitan Club, 301 Bryant Avenue, which has living and dining room accommodations for a group of foreign and American students. It is suggested that all foreign students write him before coming to Ithaca, or call on him immediately upon arrival. He will be glad to meet foreign students at the train, help them find suitable living quarters, either at the Club or elsewhere, and introduce them to other University officials, members of the faculty, and other students.

## School of Civil Engineering

EQUIPMENT The principal building occupied by the School of Civil Engineering is Lincoln Hall, containing classrooms, drafting rooms, laboratories, museums, and the working library. The library facilities include the Kuichling Memorial Library donated and endowed by Mrs. Sarah L. Kuichling in memory of Emil Kuichling, A.B., C.E. The Irving Porter Church Fund, donated by former students of the school, aids in purchasing books.

The Highway Laboratories are housed in separate buildings and are equipped for making the standard tests and for research in the field of highway engineering. Astronomical equipment in the Fuertes Observatory includes the instruments required for determining time, latitude, longitude, and azimuth.

A large and unusual Hydraulic Laboratory, situated at the outlet of Beebe Lake, is under the jurisdiction of this School. In addition to student instruction and research, this laboratory provides facilities for numerous important hydraulic investigations carried on in cooperation with governmental agencies and private companies.

The laboratories in Lincoln Hall are as follows: the Testing Laboratory, equipped for a wide variety of tests of cement, concrete, timber, structural steel, and other construction materials used by civil engineers; the Mechanics Laboratory, equipped for demonstration and experimentation in connection with the undergraduate instruction in mechanics; the Laboratory of Applied Elasticity, equipped for experimentation by advanced students; the Sanitary Laboratory, with facilities for physical, chemical, bacteriological, and biological analyses of water and sewage; and the Soil Mechanics Laboratory, with all the facilities for performing standard tests on soil. Further investigations in soil mechanics are carried on cooperatively by the School staff and the Army Engineers in another laboratory housed in a separate building constructed on the Campus by the Federal Government.

OUTLINE OF THE INSTRUCTION The object of the instruction in this School is to impart knowledge of the fundamental principles of design, construction, and operation of structures and works of the civil engineering type, in addition to providing a liberal opportunity for study of general and cultural subjects. Emphasis is placed upon civil engineering as an applied science rather than as a vocational technique.

Civil Engineering students follow the first year with as thorough a preparation as possible in the following subjects: the survey, design, construc-

tion, and operation of buildings, roads, railroads, canals, sewers, and water works; the construction of foundations under water and on land, and of superstructures and tunnels; the survey, improvement, and protection of coasts, and the regulation of rivers, harbors, and lakes; the astronomical determination of geographical coordinates for geodetic and other purposes; the application of mechanics, graphical statics, and descriptive geometry to the construction of the various kinds of arches, girders, roofs, trusses, suspension and cantilever bridges; the drainage of districts, sewerage of towns, and irrigation and reclaiming of land; the applications and tests of hydraulic and electric motors; the preparation of drawings, plans, specifications, and the proper inspection and tests of the materials used in construction. Instruction is given in engineering economy, finance, and jurisprudence. The latter subject deals principally with the fundamental principles of the law of contracts. Opportunity is also given to seniors to specialize to a limited extent, or to broaden their training, by the election of certain courses, some of which may be chosen from approved courses in any department of the University.

The instruction in mathematics, chemistry, physics, geology, economics, psychology, and English is given in the College of Arts and Sciences. All other regular subjects are taught in the School of Civil Engineering, the School of Mechanical Engineering, or the School of Electrical Engineering.

RESEARCH Undergraduates and graduates who are especially qualified and have shown proficiency in any field in Civil Engineering, may conduct special investigation under expert guidance. Such research may be used as part of the electives in the curriculum.

EMPLOYMENT AFTER GRADUATION During the emergency, the graduate may find employment in war industry or some branch of the armed services. Since such employment is under the control of the War Manpower Commission or Selective Service or the armed forces directly, no statement can be made as to where the graduate may find his services most useful.

After the emergency is over, large undertakings in highways, air fields, sanitary works, harbor and river control, and in structures will be required not only to help in absorbing the shock of demobilization, but also to transform the immense war industry back to civilian needs.

## Sibley School of Mechanical Engineering

EQUIPMENT The Sibley School of Mechanical Engineering, named in recognition of important gifts made by Hiram Sibley and his son, Hiram W. Sibley, occupies a group of buildings at the north end of the campus. In addition to the Sibley Buildings, this group includes Rand Hall, which was added through the generosity of Mrs. Florence O. R. Lang as a memorial to Jasper R. Rand, Addison C. Rand, and Jasper R. Rand, jr. The school is provided with a central working library in Sibley Dome and many of the departments also maintain special working and reference libraries.

Numerous laboratories and shops are available for carrying on the many activities of the School of Mechanical Engineering, as follows: the Materials Testing Laboratory, Heat Treatment Laboratory, and Metallography Laboratory, for determination of the physical properties of engineering materials under different kinds of stress and heat treatment; the Photoelasticity Laboratory, for instruction and research in photoelastic work; the Steam Laboratory, for instruction and research involving steam power; the Internal-Combustion Engine Laboratory, for work with this type of power equipment; the M.E. Hydraulics Laboratory, a pump-operated laboratory for hydraulic problems; the Lubrication Laboratory, for determination of the physical properties of lubricants; the Refrigeration Laboratory, for the study of refrigeration; the Fuel Testing Laboratory, for determination of the composition and calorific value of all types of fuel; the Foundry Sand Laboratory for determining the properties of various mixtures of sands and binders under the temperatures and pressures existing in foundry molds; the Micro-Motion Laboratory, for motion and time study; the Constant-Temperature Room, and the Heat Transfer, Heating, Ventilating, Air Conditioning Laboratories; a series of Research Laboratories; the Materials Processing Laboratories—formerly known as the Forge and Welding Shop, the Woodworking and Pattern Shop, the Foundry and the Machine Shop; the Laboratory Boiler House; and the University Heating Plant and Power House.

OUTLINE OF THE INSTRUCTION

The object of the instruction in this School is to lay as broad and substantial a foundation of general and technical knowledge and provide as much experience in engineering practice in the fields of Mechanical Engineering and Administrative Engineering as can be well imparted in a school.

Students of Mechanical Engineering are instructed primarily in the utilization of nature's sources of energy and materials for the benefit of mankind, through the development and application of prime movers, machinery, and processes of manufacture; thus, they have to do mainly with things dynamic. The province of the mechanical engineer includes the design, construction, operation, and testing of steam engines, steam turbines, steam generating apparatus, and power plant auxiliaries, internal combustion engines, hydraulic machines, pumping engines, railway equipment, compressed air machines, ice making and refrigerating machinery, equipment for heating and ventilating and air conditioning, machine tools, mill equipment, and transmission machinery. The work of the mechanical engineer further includes the planning of power plants and factories, the selection and installation of their equipment, the development of systems of operation and manufacturing processes, and the organization and administration of plants and industries. In addition the mechanical engineer may engage in scientific research in the innumerable branches of this field.

Based upon the fundamental instruction given in the first two terms in mathematics, physics, chemistry, drawing and materials processing, and that given in the next two terms in advanced physics, mechanics of engineering, advanced applied mathematics, materials of construction, kinematics, drawing, materials processing, machine construction, and industrial

organization and management, the student in the fifth and sixth terms receives training in fluid mechanics (including hydraulics), machine design, economic organization, industrial accounting and cost finding, heat-power engineering, electrical engineering, and the testing of engineering materials. In the final terms, the student receives training in steam power-plant engineering, internal combustion engines, refrigeration and air conditioning, and mechanical engineering laboratory practice; also provision is normally made for some degree of specialization in one of the recognized fields of mechanical engineering.

To provide for this specialization, selected groups of courses, designated as Options, have been offered in the past in Power Plant Engineering, Heat Engineering (including fluid flow, heat transmission, refrigeration, and air-conditioning engineering), Industrial Engineering, Automotive Engineering, Aeronautical Engineering, Advanced Mechanics of Engineering, Metallurgical Engineering, Mechanical Engineering Design, or in other fields allied to Mechanical Engineering; also opportunity was afforded to elect various other courses of an advanced nature. Under present circumstances, however, it is necessary to discontinue temporarily these Options, as such, although many of the courses in them are still available for election. As soon as conditions permit, the Options will be re-established; thus it is hoped that new matriculates and present lowerclassmen will find them again available when they are ready to take them.

The student in Administrative Engineering, in the field of Mechanical Engineering, pursues a curriculum which is basically one in Mechanical Engineering, but modified sufficiently to permit the incorporation of courses relating to business and industrial management. The outline of instruction in Administrative Engineering is discussed in greater detail on page 22.

EMPLOYMENT AFTER GRADUATION Because of their broad fundamental training, graduates of this school are called upon for the design, construction, operation, and testing of prime movers and other machinery, and of complete plants of many kinds, not only in their own immediate province but in the various other fields of engineering. They serve also as planners of new projects and processes, and as power plant engineers, industrial engineers, fuel and combustion engineers, automotive engineers, aeronautical engineers, refrigeration engineers, air-conditioning engineers, water-power engineers, research engineers, and teachers of engineering—to mention but a few of the many special fields open to them. Their training often serves also as an important foundation for employment in various branches of business connected directly or indirectly with engineering. The special opportunities for employment in the field of Administrative Engineering are discussed on page 22.

## School of Electrical Engineering

EQUIPMENT The School of Electrical Engineering is housed in Franklin Hall, in a portion of Rand Hall, in the High Voltage Research Laboratory, and at the Broadcasting Station and Studios. The School's library is the Alexander Gray Memorial Library, so called because it originated in a generous gift of the McGraw-Hill Book Company in

memory of Professor Gray, the first Director of the School. The library is a unit of the combined Mechanical and Electrical Engineering Library and is housed in the Sibley Dome. Laboratories and demonstration facilities of the School include the Lecture Room, with provision for experimental demonstrations to accompany the earlier lectures in electrical principles and applications; the Electrical Machinery Laboratories, with a great variety of both direct and alternating-current machines; the Electronic Laboratory, equipped for a wide variety of tests of electronic devices; the Standardizing Laboratory, for checking of secondary standards and meters; the Electrical Communication Laboratory, well provided with apparatus to illustrate modern electrical communication; and the Broadcasting Station and Studios, from which numerous University programs are broadcast, and which are available for instruction and research. The new High Voltage Research Laboratory provides excellent facilities for demonstration, tests, and research on all types of insulation and on high voltage lines, switchgear, transformers, and other apparatus.

OUTLINE OF THE INSTRUCTION

The eight-term curriculum in electrical engineering provides a strong fundamental training in the analytical study of scientific subjects common to all branches of professional engineering. On this foundation is built a coordinated program of basic work in the several branches of general engineering technology, economics, and administration, together with a major study of electrical engineering principles and their application in various fields. The study of electrical engineering proper is begun in the fourth term, as soon as the student is sufficiently advanced in the fundamental sciences, and it gradually becomes the major study. In the last six terms of the course the student receives a thorough training in electrical engineering, in addition to training in applied mechanics, machine design, thermodynamics and heat power, and mechanical laboratory. The instruction in electrical engineering is of a distinctly scientific character and requires analytical ability of a high type. Courses are given in the theory of electricity and magnetism, electrical machinery, electronic devices, rectifiers, electrical circuit analysis, mathematical applications, and the theory and practice of electrical engineering. Laboratory work serves to amplify, and is given in parallel with, the theory. Opportunity is offered to seniors to specialize to a limited extent in such subjects as application of electricity to industrial problems; electric power generation, transmission, and distribution; electric lighting; communication engineering; and research. Opportunity is also offered to qualified students who have a special liking for physics, chemistry, or mathematics to specialize in those subjects. (For curricula see page p 50.)

The student in electrical engineering also takes a large proportion of the work given to mechanical engineering students, so that he is not limited in outlook or choice of work after graduation. For those who desire a still more comprehensive study of mechanical engineering, a combined ten-term program is normally offered, leading to both the B.E.E. and B.M.E. degrees. (See page 50.)

For those desiring a broader training in general fields, including more of the liberal arts, a ten-term curriculum leading to the B.E.E. degree may be arranged, which includes the equivalent of two additional terms of liberal

arts work. A twelve-term program is also offered, leading to the A.B. degree at the end of the first eight terms, and the B.E.E. degree at the end of the twelfth term. (See page 50.)

The instruction in mathematics, physics, chemistry, and English is given in the College of Arts and Sciences. All other subjects in the regular curriculum are given in the various departments of the Sibley School of Mechanical Engineering, the School of Civil Engineering, and the School of Electrical Engineering.

Following is a brief outline of the scope and purpose of instruction in the various courses of the School of Electrical Engineering:

*Fundamentals of Electrical Engineering.* In the early work in electrical engineering the physical phenomena are demonstrated in the lecture room, and their mathematical analysis discussed. Study of lecture material and text is assigned for home work and simple problems are solved. More difficult problems are solved in the computing room under the supervision of an instructor, and the difficulties most generally encountered are clarified in recitation periods. Thus, special care is given to be sure the student has a firm grasp of basic principles and their applications, so that in the more advanced work he can think clearly for himself, with less supervision on the part of the instructor.

All electrical engineering students are given a basic course in electronics which prepares not only for later specialization in radio and communication, but also for the ever-increasing application of electronics in other fields.

The work given to civil, mechanical, and chemical engineers is no less fundamental than that given to electrical engineering students, but is necessarily less extensive and is selected and presented in sympathy with their probable needs and point of view.

*Engineering Mathematics.* As electrical engineering requires a high order of mathematical ability, the regular courses in mathematics are supplemented by courses adapted primarily for the electrical engineer. Stress is laid upon the solution of equations, determinants, Fourier and other series, and elementary differential equations.

*Advanced Electrical Engineering Theory and Practice.* In the senior year students are given training in more advanced subjects and in the application of the basic principles to give a thorough understanding of electrical apparatus and machinery.

The theoretical work covers the application of such mathematical tools as determinants, Fourier's series, symmetrical components, and dimensional analysis to engineering problems. Stress is laid upon the solution of problems of electrical and magnetic circuits, in both steady and transient states.

The principles studied in the theoretical work are applied to the detailed study of electrical apparatus and machinery, and to many of the important problems of the practicing engineer.

*Experimental Electrical Engineering.* Throughout the latter terms the student receives instruction in the electrical laboratories which closely parallels and is coordinated with the theoretical instruction. The purpose of laboratory work is to develop in the student a scientific attitude, as well

as to teach him the characteristics of the equipment and the methods of testing. The work is planned to afford constant original application of principles previously covered in theory courses.

*Electric Power.* During the last terms the student may elect an Option in Electric Power. Under this option he selects several courses which prepare primarily for later work in the power field, either with manufacturing concerns or with public utilities. Work offered under this option includes courses in the design of electrical apparatus, the transmission and distribution of electric power, and the principles of electrical power plants.

*Electrical Communication Engineering.* A student selecting the Electrical Communication Option chooses a group of courses in this field which will prepare him primarily for later work in radio, telephony, telegraphy, and related fields. The basic courses extend over two terms and provide a thorough study of communication apparatus and circuits, with particular emphasis on the application of thermionic tubes to the art. Later work treats transmission theory over wires and through the ether, radiation systems, and associated circuits. In auxiliary courses the student may specialize in a study of communication networks. These courses have recently been broadened to include work in the rapidly expanding field of ultra-high frequency radio waves which is of great importance to the nation's war effort.

*Illumination.* Electrical illumination has made rapid strides in recent years, and offers promising fields for the engineer. Courses in the engineering principles of illumination are offered and special work may be arranged.

*Elective Courses.* Elective courses in particular fields are normally given for qualified students who are particularly interested. Included among these are courses in Heaviside's operational circuit analysis, in industrial applications and control, and in the engineering aspects of patents.

*Electrical Engineering Research.* Students who have shown the requisite proficiency may conduct special investigations under expert guidance. Such work may consist of an analytic study and discussion of data, reports, and other engineering information already available, or it may be devoted to a design or construction, or both, of technical importance, or it may be an original investigation of either an analytical or experimental nature. Students who have shown proficiency in the conduct of research may be permitted (with the approval of the faculty) to substitute research for some of the senior elective and option courses.

## EMPLOYMENT AFTER GRADUATION

Graduates in Electrical Engineering find employment in many fields. In the electric power field it may be with manufacturing companies in connection with the design, construction, testing, and application of electrical equipment, or with public utilities in connection with the generation, transmission, distribution, and sale of electrical energy. They are also employed to determine the costs involved in the utilization of electricity and to investigate the rates charged for this service.

With the continued increase in use of electricity in industry, electrical engineers are needed in all industrial plants to select and install new equip-

ment for motor drives, electric heating processes, electric welding, transportation, electro-chemical and electro-metallurgical processes, etc.

In the communication field many graduates are employed in the design and manufacture of radio receiving sets and broadcasting equipment, and in the design and operation of broadcasting stations, as well as in the telephone and telegraph industries.

Men gifted with originality and scientific imagination find opportunities for employment in research and in the development of new applications for electric power.

The analytical and practical training provided in the course in electrical engineering is of great value in the field of general business, and many graduates are so employed.

## School of Chemical Engineering

EQUIPMENT The specialized training in Chemical Engineering is given in Olin Hall of Chemical Engineering. The courses in chemistry are given in Baker Laboratory of Chemistry. An unusually complete library of chemistry and chemical engineering is available. Laboratories for metallography, chemical microscopy, and other special fields of chemical engineering and chemistry provide unusual facilities for instruction and research in these special fields.

Olin Hall of Chemical Engineering was provided through the generosity of Franklin W. Olin as a memorial to his son Franklin W. Olin, jr. This modern and well-equipped building, with about 105,000 square feet of available floor space, provides lecture-room, recitation-room, and laboratory facilities for all of the instruction in chemical engineering. The unit operations laboratory, which is about one hundred feet long and fifty feet wide, extends through three floors, and houses semi-plant scale equipment for both instruction and research. It is served by a traveling crane, and by its own shops and analytical laboratory. A considerable part of the building is subdivided into unit laboratories for advanced and graduate students.

OUTLINE OF THE INSTRUCTION The purpose of the instruction in this School is to provide a broad foundation of training in the fundamental subjects of mathematics, chemistry, and physics, and in the essential principles and methods of engineering, and professional training in the specific field of chemical engineering. In the required curriculum a certain amount of work in cultural subjects is included. By providing elective work in the later years, the curriculum makes it possible for the student to take additional courses either in subjects outside the field of his major interest or in special and advanced technical subjects within that field.

Students receive during the first four terms a thorough training in the fundamental subjects upon which their specific professional work is based: mathematics, physics, introductory, analytical, and organic chemistry, English, and German. The fifth through eighth terms include more strictly technical and more advanced courses in engineering and in chemistry,

and the fundamental courses in the specific field of chemical engineering. The last two terms include the more advanced work in engineering and in the specialized field. (For an outline of the course of study see page 54.)

EMPLOYMENT AFTER GRADUATION

Graduates in Chemical Engineering find employment in the design, development, operation, and administration of chemical engineering plants. There is also some demand for men with chemical engineering training for technical sales work in connection with the selling of chemical products and chemical engineering equipment. A relatively large number of the graduates in chemical engineering continue their specialized training as graduate students in chemical engineering or in chemistry and eventually receive industrial positions as research chemists or research chemical engineers.

## Administrative Engineering

OUTLINE OF THE INSTRUCTION

The large number of engineering graduates who hold administrative positions is evidence of the usefulness of special training for these positions. Engineering methods are finding increased application in problems of executive management. This is due in part to the increasing scientific development underlying the operation of works and processes, and in part to the nature of the training of the engineer in fact-gathering and analytical study.

Students of administrative engineering in the Schools of Civil, Mechanical, and Electrical Engineering receive substantially the same basic training in mathematics, physics, chemistry, geology, economics, mechanics, surveying, shopwork, materials, etc., as do the other engineering students in these schools. In the more specialized technological subjects covered in the latter part of the regular courses in civil, mechanical, or electrical engineering the work is shortened somewhat so as to provide place for a coordinated group of courses in Business Organization and Management, Accounting, Money and Banking, Statistical Theory and Practice, Marketing, and Business Law, together with English, and Technical Writing. The aim of the program is not only to preserve the basic content and spirit of the engineering training but also to incorporate with it training in the fundamentals of industrial management. Students in the School of Chemical Engineering have opportunity to elect many of the courses in Administrative Engineering while pursuing the normal curriculum of that School.

EMPLOYMENT AFTER GRADUATION

Upon graduation, students, who take administrative engineering, whether in civil, mechanical, or electrical engineering, are qualified to accept the same types of engineering positions open to other engineering graduates. Having the basic training in the fundamentals of engineering, administrative engineering graduates can, and many do, accept positions in the more technical phases of engineering. However, the election of the student to take administrative engineering indicates a leaning toward engineering problems related to business management.

The opportunities in the field of administration for one trained as a civil engineer have been increasing with special rapidity in recent years. Railroad and public utility operation and management, highway administration, the broad field of construction, the operation and maintenance of public works, transit systems, river and harbor facilities, power developments, reclamation and conservation works, city and regional planning, and city management offer large and rapidly growing fields of administrative service for the civil engineer.

In mechanical engineering, the rapid increase in the size of the industrial concerns has created many positions for the administrative engineer between the top management and the man in the shop—positions in production engineering; in cost estimating, inventory control, and quality control; in factory planning and maintenance; in accounting and finance; or in statistical and economic studies. Furthermore, the growing importance of the selling phase of business has created a demand for the engineer trained in the principles of industrial marketing. This is a field for which administrative engineers are particularly well qualified and in which approximately 25 per cent sooner or later find employment.

In the electrical field there are many positions which require a basic understanding of electrical engineering and an understanding of human relationships. Such fields are technical sales work for electrical manufacturers, either as the employee of a large corporation or as the independent representative of smaller manufacturers; commercial work for public utilities, as in the promotion of the use of electricity for lighting, for industrial heating, or for special industrial processes; production control, cost analysis, factory management, and many other phases of manufacturing. The rapid advancement of many men in these fields in recent years indicates that opportunities are available for men who have the basic engineering training supplemented by business training and studies of economic principles.

# Admission to the College

THE METHOD OF APPLICATION

All correspondence concerning admission to the College of Engineering should be addressed to the Director of Admissions, Cornell University, Ithaca, N. Y., who will forward the necessary blank form of application on request.

An applicant for admission must not only satisfy the entrance requirements of the College of Engineering, which are outlined below, but must also comply with the University's rules governing admission. These rules require, of every applicant for admission to an undergraduate course of study, (1) a certificate of good character, (2) a deposit of $25, and (3) a certificate of vaccination against smallpox. These rules are fully and clearly stated in the University's *General Information Number*, which every candidate for admission should read carefully and which can be obtained by application to the Secretary of the University.

THREE WAYS OF ENTRANCE

There are three ways of satisfying the entrance requirements. They are fully described in the University's *General Information Number*, which every candidate for admission is advised to consult. In brief they are as follows:

1. By passing the examinations of the College Entrance Examination Board in the required subjects.

2. By passing the necessary Regents examinations. This option is for students who have prepared in New York State.

3. By presenting an acceptable school certificate.

SELECTIVE ADMISSION

The number of applicants admitted to the several schools of the College of Engineering is limited by the facilities available for adequate instruction. The Committee on Admissions in each of the Schools will exercise discretionary power in selecting those to be admitted. Preference will be given to those candidates whose academic preparation and personal character indicate fitness to pursue with success the course of study to be undertaken, who show evidence of professional promise, and who complete the filing of their entrance credentials in ample time for the Admission Committee to give thorough consideration to their qualifications.

ADMISSION AS A FRESHMAN

For admission to the freshman class in an eight-term or ten-term curriculum in engineering an applicant must be at least sixteen years of age and must offer fifteen specific units of entrance subjects, as follows:

| | | |
|---|---|---|
| English (four years) | | 3 units |
| Mathematics: | | |
| Elementary Algebra | 1 unit | |
| Intermediate Algebra | 1 " | |
| Plane Geometry | 1 " | |
| Advanced Algebra or Solid Geometry | ½ " | |
| Plane Trigonometry | ½ " | |
| Total, Mathematics | | 4 units |
| History, 2 units, or | | 2 units |
| One Foreign Language*, 2 units | | |
| (German, French, Spanish, Italian, Greek, or Latin) | | |
| Physics or Chemistry** | | 1 unit |
| Electives | | 5 units |
| Total | | 15 units |

With respect to the specific list of entrance subjects the following paragraphs should be noted:

1. *Mathematics.* The four units of Mathematics required may be offered under the specific subjects and units above listed, or they may be offered as four years of continuous training in Mathematics throughout the high or preparatory school course, provided that in the latter case a declaration is attached to the certificate of credits stating that the course in Mathematics has included the essentials of the four units of Mathematics as required by the Gamma Examination of the College Entrance Examination Board.

2. *Elective Units.* The five elective units may, with one exception, be made up of any of the entrance subjects and units acceptable to Cornell University. For a list of those subjects and units, see the *General Information Number* (Table 1, on page 5.) The one exception is that credit for a single unit in a foreign language will not be granted unless the candidate offers three units in another foreign language or two units in each of two other foreign languages.

3. *Special Consideration of Units.* Applicants offering fifteen units which do not differ materially from the specific list may present their credits for special consideration, for under proper circumstances some adjustment may be permitted. If there is a deficiency of one-half unit in Advanced Algebra or Solid Geometry, the applicant may be admitted, taking the shortage as extra work during the first term, provided his scholastic standing is sufficiently high to indicate that this program can be carried successfully. This adjustment requires the special approval of the School which the student desires to enter. However, the student is strongly urged to be free of entrance shortages at the time he enters. Attention is called to the possibility

*Students who expect to enter the Graduate School after obtaining a first degree should note that although there are no foreign language requirements for the masters' degrees in Engineering, proficiency in two, preferably German and French, is required for the doctorate.

**Candidates for admission to the School of Chemical Engineering *must* offer one unit of Chemistry, and should offer also one unit of Physics.

of obtaining additional credits by attending the Summer Session (see the *Announcement of the Summer Session*) or by taking the September examinations.

4. *French or German Recommended.* It is recommended that if foreign language units are offered they be in French or German, for the reason that a knowledge of either of these tongues gives the student immediate access to important literature on the theory and practice of engineering. For the purpose of entrance requirements, the substitution, unit for unit, of scientific French or German is permitted, in lieu of a more general literary course in either of those subjects, and this substitution will apply to all such courses in any secondary schools approved by the Director of Admissions.

5. *Language and History.* The student preparing to enter the College of Engineering is strongly advised to offer at least three of his elective units in Language and History. His work in the eight-term curriculum in engineering will of necessity be largely scientific or technical. He will therefore do well in his preparatory years to avoid unnecessary specialization and to make his studies as liberal as possible. Applicants who have not had this broader education are recommended to take either a ten-term or twelve-term curriculum. See page 10.

6. *Practical Experience.* Students who have had some practical experience in engineering usually gain more than others from the courses offered by the College of Engineering. It is therefore recommended that prospective students spend at least one summer vacation in practical work in connection with some kind of engineering.

TWELVE-TERM CURRICULA

The requirements for entrance to one of the twelve-term curricula, leading to the degree of Bachelor of Arts and one of the bachelor's degrees in Engineering (B.C.E., B.M.E., B.E.E., or B.S. in A.E.), are those of the College of Arts and Sciences, where the candidate for the two degrees is registered during the first eight terms.

ADMISSION FROM ANOTHER COLLEGE

A student who has attended another college may be admitted to advanced standing, provided he is in good standing and has made a satisfactory scholastic record in the college from which he comes and provided also that he meets the full entrance requirements of the College of Engineering. An applicant for admission in this way should file by mail with the Director of Admissions of Cornell University, on an official blank to be obtained from him, a formal application for admission stating definitely the branch of engineering desired, and should include (1) an official certificate, from the college or university already attended, of his honorable dismissal, his entrance credits in detail, his terms of attendance and the amount of work that he has completed, (2) a detailed statement of the courses pursued, and (3) the drawings and reports for which credit is desired. He should also send a catalogue of the institution attended, writing on it his name and marking the entrance requirements that he has satisfied and each subject that he has completed.

SPECIAL STUDENTS

Applicants who do not wish to become candidates for any of the undergraduate degrees may, in exceptional cases, be admitted to the College of Engineering as special students.

Such students may be of two classes:

1. Those students who can not meet the entrance requirements or do not wish to spend the required time to complete the course. Special students of this kind must be at least 21 years of age, must have had some engineering training, and must have the prerequisites for the courses they wish to take.

2. Those students who, having a baccalaureate degree, wish to pursue further work at the undergraduate level. Such students must have the prerequisites for the courses they wish to pursue.

It is further provided that all special students must register for a minimum of 15 credit-hours of work each term, and pay the same tuition and fees required of other undergraduate students. Special students may not receive a degree except upon the completion of both the entrance requirements and the undergraduate work specified for that degree.

# Payment to the University

TUITION FEE. For instruction in the College of Engineering during the regular session the University charges a tuition fee at the rate of two hundred dollars a term. For all the rules concerning the payment of the tuition fees see the *General Information Number.*

OTHER FEES. For certain services or privileges which the student enjoys the University charges fees over and above that charged for tuition. (See the *General Information Number.*) Every undergraduate student of the College of Engineering is required to pay fees as follows:

*A Matriculation and Examination Book Fee* of $11 is required of every student upon entrance to the University. This fee must be paid at the time of registration. A new undergraduate student who has made the required deposit of $25 with the Treasurer does not make an additional payment of this fee, because the Treasurer draws on the deposit for it.

*A Health and Infirmary Fee* of $10 a term is required at the beginning of each term.

*A Willard Straight Hall Membership Fee* of $5 a term is required at the beginning of each term.

*A Physical Recreation Fee* of $4 a term is required at the beginning of each term.

*A Laboratory Fee* is required to be paid at the beginning of each term at the following rates: first two terms in the School of Civil Engineering, $12.50; all students in Mechanical Engineering and Electrical Engineering, $12.50, but not for more than eight terms; students in the last six terms of the curriculum in Chemical Engineering, $12.50; students in the last six terms in Civil Engineering, $4. The term fees in Physics courses are $5 for the first and second terms, and $2.50 for the third and fourth terms. Fees are also charged for Engineering Geology ($4.50), Public Speaking ($2), and some of the elective courses.

*The Shop Instruction Fee* for non-engineering students is $3.50 a credit hour.

*Automobile Registration and Parking.* See Automobile Regulations in the *General Information Number.*

STUDENTS ENTERING MILITARY SERVICE. The student shall be obligated for $\frac{1}{16}$th of the term's tuition for each week or fraction thereof, between the first day upon which he receives instruction to the date of his certificate of withdrawal as issued by his college.

DEPOSITS *Laboratory Deposits.* In some courses, particularly in Chemistry, the student is required to make in advance at the Treasurer's office a deposit of money to cover the cost of material to be used and supplies to be consumed by him in the course of the term. Accounts are kept and charges are entered against the deposit. At the end of the term any balance remaining of the deposit is returned to the student. Freshmen in the Schools of Civil, Electrical, and Mechanical, including those taking the Administrative Engineering, deposit $11 a term for first-year Chemistry. Students in Chemical Engineering make additional deposits.

*R.O.T.C. Uniform Deposit of $20.* Every student enrolled for the Basic Course of Instruction in Military Science and Tactics is required to deposit $20 at the Treasurer's office for the purchase of his military uniform. An immediate deposit is required because enrollment in the Department of Military Science and Tactics takes place at once. Most of the amount of the student's deposit is returned to him as earned uniform allowance upon his completion of the four-term Basic Course.

LIVING COSTS The average student's allowance for the necessary expenses of the normal term at Ithaca should be from $500 to $600, but much depends on the students personal tastes. This subject is discussed at length in the *General Information Number.*

# Means of Financial Aid

AID FOR NEW STUDENTS

Cornell University's provision of financial help for new students of the College of Engineering consists of certain scholarships which are awarded on the basis of competition, many of them to students entering the freshman class. Prospective freshmen are eligible to compete for twenty-five University Undergraduate Scholarships, 150 State Cornell Scholarships for residents of the State of New York, and a few others, most of which are restricted to residents of certain localities. The John McMullen Regional Scholarships in Engineering are available for new students coming from outside New York State.

*John McMullen Regional Scholarships* are awarded annually to thirty or more selected students entering the College of Engineering. Entering male students whose preparatory work was completed at a school outside New York State and those students from New York Schools who are ineligible, at the time they enter, for the Cornell Tuition Scholarships and the State Cash Scholarships offered by the State of New York are eligible to compete. These scholarships have variable stipends up to $200 a term and may be held throughout an undergraduate course of study, provided the recipient maintains the required academic record. They were established by the Board of Trustees from a portion of the income of a munificent gift to the University by the late John McMullen of Norwalk, Connecticut, and are allotted among fifteen districts of the United States. A student is not eligible for both the State and McMullen Regional Scholarships at the same time. Application blanks and instructions are sent, about January 1 of each year, to the principals and headmasters of accredited schools for their use in recommending outstanding candidates who wish to enter the College of Engineering. An application blank will also be sent direct to the candidate upon request to the Committee on Scholarships, College of Engineering. The applications are to be returned to the Chairman, Committee on Scholarships, before March 1. The candidates selected by the Committee for final consideration are requested to take the Scholastic Aptitude Test of the College Entrance Examination Board in April. These candidates are also interviewed by members of an alumni scholarship committee in their respective districts. Final selections are made by the Committee on Scholarships, and the Dean, based upon the secondary school record, the aptitude test, and the qualities of character and general ability, as determined by the personal interview. The successful candidates are appointed by the President of the University.

*The John McMullen Industrial Scholarships in Engineering* are awarded each year to four graduates of secondary schools who have spent some time in industry and have had apprentice training, preferably in a formal course given by an industrial concern. Candidates must be sponsored by responsible officers of the companies by which they have been employed. Each scholarship has a value of $200 a term, and may be held throughout an undergraduate course of study provided the recipient maintains the required academic record. Inquiries should be addressed to the Chairman,

Committee on Scholarships, College of Engineering, preferably not later than February, so that formal applications may be filed with the Committee on Scholarships before April 1.

For particulars of all other scholarships that are open to new students, the *General Information Number* should be consulted.

GRANTS AND OTHER AID

Students who establish superior academic records become eligible for John McMullen Regional Scholarships after one term of residence, regardless of the State in which they reside. Other scholarships, grants, and loans open to undergraduates are reserved for students who have been in residence and good standing at Cornell University for at least two terms.

Any student in the College of Engineering who needs financial aid should immediately consult the Director of his School. Ordinarily a single application is sufficient to assure consideration for all available scholarships and grants. When this is not true, the Director will instruct the student as to the proper procedure for making application. Scholarship applications for the following year received before April 1 will be given primary consideration. Late applications can be considered only for vacancies.

Certain grants are drawn from the income of special funds, the gifts of persons who in many instances have specified to whom in general their benefits are to apply. They are not as a rule available for aid to freshmen.

Much of the financial aid which the University is able to give undergraduate students is in the form of loans from the income of endowments which are administered for the Trustees by the standing Committee on Student Aid, of which the Counselor of Students for men is Chairman. The benefits of these funds are reserved for students who have been in residence and in good standing at Cornell University for at least two terms, and preference is given to applicants of high scholastic standing who are within a year of graduation.

To help solve the financial problem caused by the addition of a third term each year and the elimination of possible summer earnings, the College and University have arranged for the regular payment of John McMullen Regional and Industrial Scholarships during all three terms each year. Holders of State Cash and Tuition Scholarships may have their scholarship payments accelerated so that they will receive scholarship aid for eight terms even though the total period between entrance and graduation is less than four years. In addition to these adjustments of existing scholarships, the College of Engineering has eliminated the John McMullen Undergraduate Scholarships and has established in their place a number of John McMullen War Scholarships of a value of $100 a term. These scholarships may be awarded to students who have been in residence at least one term, and awards may be made for a period of one, two, or three terms.

Some of the normal scholarships, grants, and loan funds, donated for the special purpose of helping students in the College of Engineering, are listed below. A list of others available to students of several colleges, including engineers, is given in the *General Information Number*.

*John McMullen Regional Scholarships* of variable stipends up to $200 a term are available to male students in any class in the College who have been in attendance at least

one term and who make superior academic records, regardless of their place of residence. Applications may be filed with the Director of the school involved at any time before April 1.

*The John McMullen War Scholarships:* To assist undergraduates in the College of Engineering who are unable to carry the financial burden imposed by the accelerated program. Stipend $100 a term, for a period of 1, 2, or 3 terms. Award of these scholarships will be based upon financial need and the scholastic record of the applicant. Application may be made at any time during the year, to the Director of the School concerned.

*The Frank William Padgham Scholarship:* Open to undergraduates in the Sibley School of Mechanical Engineering or the School of Electrical Engineering. This scholarship consists of the income of a fund of $3,000 given by Amos Padgham, of Syracuse, New York, in honor of his son, Frank William Padgham, M.E. '88, and is to be applied toward the tuition and regular fees in engineering. It will be awarded to the best qualified applicant who shall have had preparatory education in the public schools of Syracuse, New York, and may be held throughout the period of the course, if the holder remains in good standing. If no candidate from Syracuse applies, it may be awarded for not more than one year to an eligible student residing elsewhere in New York. Application should be made to the Committee on Scholarships, College of Engineering, before April 1.

*The Fred Lewis Wilson Scholarship:* Open to undergraduates in Mechanical or Electrical Engineering. Mrs. Mary Northrup Wilson bequeathed Cornell University about $4,000 to found and perpetuate one or more scholarships in honor of her son, Fred Lewis Wilson, who was graduated from Sibley College with the class of 1892. These scholarships are awarded, for a period of not more than two years each, to undergraduates who have been at least one year in the University. Applications should be made to the Director of the school concerned before April 1.

*The John Leisenring Wentz Scholarship:* Open to undergraduates in Mechanical or Electrical Engineering; consists of the income of a fund of $5,500, given the University in 1920 by Mrs. Lewis Audenried in memory of John Leisenring Wentz, a member of the class of 1898. It is awarded at the end of each academic year to a member of the incoming senior class who is in need of pecuniary aid; the beneficiary must have maintained a high scholastic standing during his junior year. Applications should be made to the Director of the school concerned before April 1.

*The William Delmore Thompson Scholarship:* Open only to undergraduates in Mechanical Engineering; established in memory of William Delmore Thompson of the class of 1918; pays $40 a year and is for the benefit of self-supporting students of mechanical engineering. It is awarded at the beginning of the junior year, and if the student's work proves satisfactory it is continued through the senior year. Applications should be made to the Director of the School of Mechanical Engineering before April 1.

*The Judson N. Smith Scholarship:* Open to upperclassmen in the School of Civil Engineering; pays $160 a year, the income of a fund given by Mrs. Sarah L. Smith of Saranac Lake, New York, in memory of her son. It is awarded by the Faculty of the School of Civil Engineering at the end of each year to a student of the incoming senior or junior class in that school, of good character and scholarship and needing pecuniary aid. Applications must be made to the Director of the School of Civil Engineering before April 1.

*Otto M. Eidlitz Scholarships:* Open to undergraduates in the College of Engineering. These scholarships were founded in 1929 by a bequest of Otto M. Eidlitz, C.E. '81, of $25,000 to Cornell University to establish a scholarship fund in the College of Engineering for students who require financial assistance. With the avails of this bequest three scholarships of an annual value of $325 have been established. These scholarships are awarded by the Dean of the College of Engineering to such students as appear to be most deserving because of their character and intellectual promise. Applications should be made to the Director of the school concerned before April 1.

*The Sylvester Edick Shaw Scholarship*, the income of a fund of $4,000 given in 1929 by Sylvester Edick of Newfane, is awarded to a student designated by the alumni of Cornell University who are residents of Niagara County at the time of the award. If the alumni fail to make such designation, the award is made by the principal of the Lockport High School, preference being given to the student who is most in need of financial assistance and who is studying Mechanical or Electrical Engineering. The student has the benefit

of the scholarship for the entire period of his course, provided his conduct and progress in his work are satisfactory. Applications should be made to the Committee on Scholarships, College of Engineering, before April 1.

*The Joseph N. Evans Scholarship*, consisting of the annual income from a bequest of $3,000 given by the will of Mrs. Joseph N. Evans in memory of her husband. Open to any undergraduate in the College of Engineering. Applications should be made to the director of the school concerned before April 1.

*The Redmond Stephen Colnon Scholarships:* Supported by the income from $20,000 bequeathed by Mrs. Katharine Fruin Colnon in 1935 in memory of her husband. Four scholarships of $200 each are awarded annually (two in Mechanical Engineering and one each in Civil and Electrical Engineering) to sophomores, juniors, or seniors, upon the recommendation of the school concerned. Candidates in order to be eligible must be upon the annual Honor List, and may hold the scholarships for more than one year provided they remain upon that list. Applications should be made to the director of the school concerned before April 1.

*The Carl Richard Gilbert Award* was founded in 1929 by Mr. and Mrs. A. S. Gilbert in memory of their son, Carl Richard Gilbert, who died during his junior year. The value of the award is about $190 annually and is available for students in the School of Electrical Engineering. Awards from this fund are made on the recommendation of the Dean of the College and the Director of the School of Electrical Engineering, and with the approval of the Faculty of Engineering, to one or more worthy students each year. Application should be made to the Director of the School of Electrical Engineering.

*The William C. Seidell Book Fund* of $1,425 was founded by Gerrit S. Miller. The income is used for the purchase of books for young men who are working their way through the School of Civil Engineering, and is paid upon the recommendation of the Director of the School, preference being given to underclassmen.

*The Chemical Engineering Loan Fund* was founded in 1938 by alumni interested in Chemical Engineering. It is available to students in the School of Chemical Engineering. Application should be made to the Director of that School.

*The Robert Critchlow Dewar Loan Fund* was founded in 1915, the joint gift of Mrs. James M. Dewar and the Cornell Society of Engineers, in honor of Robert Critchlow Dewar, C.E. '09. It is available to undergraduates in the School of Civil Engineering. Applications should be made to the Director of that School.

*The Martin J. Insull Loan Fund* was founded in 1924 by Martin J. Insull, M.E. '93, for students in the College of Engineering, and particularly those in the Sibley School of Mechanical Engineering. Application should be made to the Director of the school in which the applicant is registered.

*The John N. Ostrom Loan Fund* was founded in 1937 by John N. Ostrom, C.E. '77, for students in the School of Civil Engineering. Application should be made to the Director of that School.

*The Wurts Loan Fund* was founded by Alexander Jay Wurts in 1912, in memory of his mother, Laura Jay Wurts. It is available to students in the two upper classes of the Sibley School of Mechanical Engineering and the School of Electrical Engineering. Application should be made to the Director of the school in which the applicant is registered.

*The Herman Diederichs Loan Fund* was founded in 1939 by the Southern Tier Chapter of the American Society for Metals in memory of Herman Diederichs, M.E. '97, late Dean of the College of Engineering. The fund is available for loans to deserving students who have shown a genuine interest and aptitude in the field of metallurgy. Application should be made to the Director of the school in which the applicant is registered.

*The Samuel Wiley Wakeman Loan Fund* of $10,000 was bequeathed in 1940 by Samuel Wiley Wakeman, M.E. '99, whose will directed that the gift be held as a permanent fund, the income of which is to be loaned to male members of the second year class of the Sibley School of Mechanical Engineering. Applications should be made to the Director of the Sibley School of Mechanical Engineering.

*The Lillian S. Mennen Memorial Fund*, founded in 1937 by William G. Mennen, M.E. '08, as a memorial to his mother, provides loans preferably to juniors and seniors major-

ing in Chemistry (in the College of Arts and Sciences), Chemical Engineering, and Administrative Engineering, from the State of New Jersey; otherwise to other engineering students who are exceptionally qualified. Applications should be made to the Director of the school in which the student is registered.

PRIZES Cornell University has a considerable number of funds given for the endowment of prizes to be awarded annually. Some of these prizes are open to competition by students of the University generally. The Secretary of the University publishes a list of them under the title *Prize Competitions*, a copy of which will be mailed on request addressed to his office. Other prizes are open to competition particularly by students of the College of Engineering, as follows:

*The Fuertes Medals*, established by the late Professor E. A. Fuertes. The endowment provides for two gold medals. One is awarded annually by the Faculty to that student of the School of Civil Engineering who is found at the end of the first term of his senior year to have maintained the highest degree of scholarship in the subjects of his course, provided he has been in attendance at the University for at least two years. The other is awarded annually by the Faculty to a graduate of the School of Civil Engineering who has written a meritorious paper upon some engineering subject tending to advance the scientific or practical interests of the profession of the civil engineer. It is desired that papers be presented on or before April 15. If a paper is presented in printed form it will not be received if it has been printed earlier than the next preceding April 15. Neither medal is awarded unless it appears to the Faculty of the School of Civil Engineering that there is a candidate of sufficient merit to entitle him to such distinction.

*The Fuertes Memorial Prizes in Public Speaking*, founded by the late Charles H. Baker, a graduate of the School of Civil Engineering of the class of 1886. Three prizes, one of $80, one of $40, and one of $20, are offered annually to members of the Junior and Senior classes in the Colleges of Engineering and Architecture for proficiency in public speaking.

*The Charles Lee Crandall Prizes*, founded in 1916 by alumni of the School of Civil Engineering; prizes of $75, $50, $35, and $20. They are awarded each year, by a committee appointed by the Director of the School of Civil Engineering, for the best papers written by seniors or juniors in that school on suitable subjects, provided that both the substance and the written form of the papers submitted show real merit. The prizes were established to encourage original research, to stimulate interest in matters of public concern, and to inspire in the students an appreciation of the opportunities which the profession of civil engineering offers them to serve their fellow men as intelligent and public-spirited citizens. Papers must be submitted to the Director of the School of Civil Engineering on or before May 1 of each year.

*The Sibley Prizes in Mechanic Arts* are offered to undergraduates in Mechanical and Electrical Engineering. Under a gift of Hiram Sibley, made in 1884, the sum of $100 is awarded annually in several prizes to juniors and seniors in the School of Mechanical Engineering and in the School of Electrical Engineering who have received the highest marks in scholarship in at least three full terms of work.

*The J. G. White Prize in Spanish.* Through the generosity of James Gilbert White (Ph.D., Cornell, '85) three prizes, established in 1914, each of the value of $100, are offered annually. One of the three, which is awarded to an English-speaking student for proficiency in Spanish, is open to members of the junior and senior classes in the College of Engineering who are candidates for their first degree. No candidate is eligible unless he has completed successfully two terms of work in Spanish at Cornell University.

*The Robert Harris Simpson Prize*, founded in 1933 by Mrs. Simpson in memory of her late husband, Robert Harris Simpson, C.E. '96. This prize of $25 is awarded annually to that senior in the School of Civil Engineering who submits the best technical description or design of a civic improvement of sufficient substance and merit to justify the award. Papers or designs must be submitted on or before December 15 of each year and are judged by a committee appointed by the Director of the School of Civil Engineering.

## Officers

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*Office: Sibley Dome*

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LAWRENCE HIMMEL, Assistant in Chemical Engineering.
MARION JAMES STOOKER, Assistant in Chemical Engineering.

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J. V. LARKIN, Administrative Assistant.
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LULU MARKELL, Clerk, Dean's Office.
DORIS HOPPER, Secretary, Personnel and Employment Office.

DOROTHY M. HENDRICKSON, Secretary to the Director of the School of Civil Engineering.
L. WILMA GRENOLDS, Librarian of the School of Civil Engineering.
LILLIAN H. LEHMANN, Secretary to the Director of the Sibley School of Mechanical Engineering.
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### MEMBERS OF THE EXPERIMENT STATION STAFF, 1943–44

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HENRI S. SACK, D.Sc., Westinghouse Research Associate.
WOLFGANG STERNBERG, Ph.D., Westinghouse Research Associate.

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DONALD MACLEON DEWART, B.S. in C.E.
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RICHARD PIAN, B.S.C.E., M.S. in Engineering
RICHARD NICHOLAS WORK, A.B.

## HOLDERS OF OTHER GRADUATE SCHOLARSHIPS AND FELLOWSHIPS, 1943–44

CHUNG-JUI CHU, B.S in C.E., D.I.C., McGraw Fellowship.
MATEO LEON-POA GO, B.C.E., M.C.E., Graduate-Tuition Scholarship in C.E.
KALELKAR, BAL DATTATREY, B.M.E., Edgar J. Meyer Memorial Fellowship in Engineering Research.
WING CHING LAM, B.S. in M.E., Sibley Fellowship in Mechanical Engineering.
DOUGLAS CAMPBELL WILLIAMS, B.S. in Chem., American Foundrymen's Association Research Fellow.

# School of Civil Engineering

THE COURSES OF STUDY

The courses of study offered by the School of Civil Engineering lead to the degrees of Bachelor of Civil Engineering, Bachelor of Science in Civil Engineering, or the Bachelor of Science in Administrative Engineering. The courses are all planned to provide fundamental instruction for the practice of the profession.

The degree of Bachelor of Civil Engineering is granted to those who successfully complete the four years work covered by the outline following. The Degree of Bachelor of Science in Civil Engineering is granted to those students who complete the outline covered by the Navy V-12 program or its equivalent. Information on such program may be obtained from the Director of the school. The Degree of Bachelor of Science in Administrative Engineering has been placed in abeyance for the duration of the emergency.

In normal times, special options in Administrative Engineering, Sanitary Engineering, Structural Engineering, Hydraulic Engineering, Transportation Engineering, Geodetic Engineering are offered. Owing, however, to the necessity of giving practically all required courses every term, it is not possible for students to take such options. Faculty action has placed all options in abeyance. Thus, for the duration of the war electives will be selected from a comparatively few specialized courses. Lists of courses that can be used as electives will be issued at the end of each term and prior to new registration.

The junior inspection trip has had to be abandoned for the duration of the war, and the summer survey camp has been replaced by special work on the campus.

This curriculum does not include Physical Training or Military Science and Tactics. All students, unless exempted, are required by university action to take the latter for the first four terms, three hours a week. Physical training is required for all eight terms, two hours a week for the first four terms and three hours a week for terms five to eight inclusive. Credit hours of 1 a term for Military Science and Tactics are included in calculating all term and final average grades. Grades in Physical Training are not so included.

## Eight-Term Curriculum (B.C.E.)

| | | HOURS | |
|---|---|---|---|
| | | *First Term* | *Second Term* |
| TERMS 1 & 2 36 HOURS | Mathematics 55a and 55b | 5 | 5 |
| | Physics 11 and 12 | 4 | 4 |
| | Chemistry 1a and 2a | 4 | 2 |
| | Drawing 200 and 201 | 3 | 3 |
| | Surveying 210 and 211 | 3 | 3 |
| | Total number academic hours a term | 19 | 17 |

In addition to taking the above courses all Freshmen must satisfy the University's requirements in Physical Training and in Military Science and Tactics.

| | | *Third Term* | *Fourth Term* |
|---|---|---|---|
| TERMS | Public Speaking 1 | 3 | 0 |
| 3 & 4 | English 2 | 0 or 3 | 3 or 0 |
| 36 HOURS | Engineering Geology 501 | 3 | 0 |
| | Field Astronomy 182 | 0 | 2 |
| | Drawing 204, 203 | 3 | 2 |
| | Mechanics 220, 220B | 6 | 0 |
| | Mechanics 221, 221A | 0 | 5 |
| | Route Surveying 260B | 3 or 0 | 0 or 3 |
| | Engineering Construction 264 | 0 | 3 |
| | Economics 3 | 0 | 3 |
| | Total number academic hours a term | 18 | 18 |

In addition to these courses, third and fourth term students are required to take Military Science and Tactics and Physical Training.

| | | *Fifth Term* | *Sixth Term* |
|---|---|---|---|
| TERMS | Summer Surveying 213A | 3 or 0 | 0 or 3 |
| 5 & 6 | Materials 225 | 3 | 0 |
| 35 HOURS | Materials Laboratory 226 | 3 | 0 |
| | Hydraulics 240 | 4 | 0 |
| | Structural Analysis 270 | 4 | 0 |
| | Structural Design 271 | 0 | 3 |
| | Soil Mechanics 287 | 0 | 3 |
| | Treatment of Water (N.C.E. 14) 253A | 0 | 3 |
| | Sewerage and Sewage Treat. 252 | 0 | 3 |
| | Concrete Construction 280 | 0 or 3 | 3 or 0 |
| | Elective | 0 | 3 |
| | Total number academic hours a term | 17 | 18 |

In addition, fifth and sixth term students must take the required Physical Training.

| | | *Seventh Term* | *Eighth Term* |
|---|---|---|---|
| TERMS | Electrical Equipment 418 | 3 | 0 |
| 7 & 8 | Heat-Power Equipment 3P43 | 0 | 3 |
| 34 HOURS | Engineering Management 293 | 3 | 0 |
| | Water Supply 230 | 0 | 2 |
| | Highway Engineering 265 | 3 | 0 |
| | Foundations 281 | 0 | 3 |
| | Engineering Law 290 | 3 | 0 |
| | Engineering Problems 223 | 0 | 2 |
| | Electives | 6 | 6 |
| | Total number academic hours a term | 18 | 16 |

In addition, seventh- and eighth-term students must take the required Physical Training.

Grand total for eight terms ..... 141 academic hours
(not including Military Science and Tactics and Physical Training)

# Sibley School of Mechanical Engineering

CURRICULA The regular eight-term curricula offered in this school lead either to the degree of Bachelor of Mechanical Engineering or that of Bachelor of Science in Administrative Engineering. By attending one or more additional terms the student may obtain one of these degrees with the benefit of supplementary instruction in other studies, generally in the College of Arts and Sciences, thereby broadening his education. In ten terms the student may obtain two engineering degrees, the B.M.E. and B.S. in A.E., or the B.M.E. and B.E.E. In twelve terms the degrees of A.B. and B.M.E., or of A.B. and B.S. in A.E., may be secured. Students who can afford the additional time and expense are urged to pursue one of these longer and broader programs.

EIGHT-TERM CURRICULA The eight-term program leading to the degree of *Bachelor of Mechanical Engineering* contains the courses of instruction in English, mathematics, physics, chemistry, mechanics, materials, drafting, materials processing, kinematics and machine design, heat-power engineering, electrical engineering, experimental engineering, economics, and industrial organization and management, that are considered essential to the basic training for this degree. Provision is normally made in the later terms of the course for specialization in any one of several recognized fields of mechanical engineering, for the student who may develop a special interest in one of those fields, but this specialization is strictly limited in extent and is not permitted to encroach upon the mastering of the broad fundamentals, which is considered of primary importance. In the past, each senior in mechanical engineering has been permitted to devote about one third of his time to a group of specialized courses in one of the following Options: Aeronautical Engineering, Automotive Engineering, Engineering Mechanics, Heat Engineering (including Air Conditioning), Industrial Engineering, Mechanical Engineering Design, Metallurgical Engineering, and Power Plant Engineering. Under prevailing conditions, however, it has become necessary to discontinue the Options temporarily, but with expectation that they will be reestablished before new matriculates and present lower classmen become ready for them. Meanwhile, many of the Option courses are still available for election by upperclassmen.

The eight-term program leading to the degree of *Bachelor of Science in Administrative Engineering* is basically a course in Mechanical Engineering, but with some of the more specialized engineering courses shortened somewhat. This curtailment, together with the utilization of the elective hours available in the M.E. curriculum, provide for a coordinate group of courses in the technique of industrial and business management. This special instruction in administrative engineering includes courses on technical report writing, industrial statistics, industrial organization and management, economic organization, industrial accounting and cost finding,

principles of cost control, industrial relations, industrial engineering, motion and time study, standard costs and management control, corporation finance, engineering business law, and personnel management.

## First and Second Terms

The schedule for the first two terms of instruction is the same for all candidates for the degrees of Bachelor of Mechanical Engineering and Bachelor of Science in Administrative Engineering offered in this school (see below). It is the same as that for the first two terms in the School of Electrical Engineering; hence a change of candidacy from one degree to another within these schools may be accomplished without complication if effected before starting the third term. As the first and second-term programs in Civil and Chemical Engineering differ somewhat from those in Mechanical Engineering, a student transferring from one of these schools to this one will not be able to obtain a degree at the end of the eighth term under normal conditions unless he changes prior to the third term and subsequently makes up the program differences by receiving instruction during one or more summer vacation periods. Under the accelerated program an additional term of residence may be necessary.

The schedule for the first two terms of the curricula in Mechanical Engineering and Administrative Engineering (in M.E.) follows:

| | | HOURS | |
|---|---|---|---|
| | | *First Term* | *Second Term* |
| TERMS 1 & 2 36 HOURS | English NE1, NE2, E1, E2 | 3 | 3 |
| | Analytic Geometry and Calculus 60a, 60b | 3 | 3 |
| | General Physics 11, 12 | 4 | 4 |
| | General Chemistry 1a, 2a | 4 | 2 |
| | Drawing and Descriptive Geometry 3C11 | 3 | 0 |
| | Mechanical Drafting 3C12 | 0 | 3 |
| | Elementary Surveying 210A | 0 or 1 | 1 or 0 |
| | Metal Working 3S11 | 0 or 1 | 1 or 0 |
| | Casting Processes 3S15 | 2 or 0 | 0 or 2 |
| | Total number of hours a term | 19 | 17 |

In addition to taking the above courses all Freshmen must satisfy the University's requirements in Physical Training and in Military Science and Tactics. (See the *General Information Number*.)

The courses in Mathematics, Physics, and Chemistry are given in the College of Arts and Sciences. All the others except Military Science and Physical Training are given in the College of Engineering.

# Eight-Term Curriculum (B.M.E.)

| TERMS | | HOURS *First Term* | *Second Term* |
|---|---|---|---|
| 1 & 2 | | | |
| 36 HOURS | See page 47 | 19 | 17 |

| TERMS | | *Third Term* | *Fourth Term* |
|---|---|---|---|
| 3 & 4 | Analytic Geom. and Calculus 60c | 3 | 0 |
| 37 HOURS | Mechanics 3M21 | 5 | 0 |
| | Strength of Materials 3M22a | 0 | 3 |
| | Physics 21, 22 | 3 | 3 |
| | Kinematics, Recitations 3D25 | 0 or 3 | 3 or 0 |
| | Kinematics, Drawing 3D26 | 0 or 2 | 2 or 0 |
| | Engineering Materials 3T21, 3T22 | 3 | 3 |
| | Machine Tool Processes 3S23 | 2 or 0 | 0 or 2 |
| | Measuring Instruments 3S24 | 1 or 0 | 0 or 1 |
| | Applied Mathematics 3M24 | 0 | 3 |
| | Industrial Organization and Management 3A25a | 3 or 0 | 0 or 3 |
| | Total number of academic hours a term | 20 or 19 | 17 or 18 |

In addition to these courses, third- and fourth-term students are required to take Military Science and Tactics and Physical Training.

| TERMS | | *Fifth Term* | *Sixth Term* |
|---|---|---|---|
| 5 & 6 | Strength of Materials 3M22b | 2 | 0 |
| 36 HOURS | Heat-Power Engineering 3P35, 3P36 | 3 | 3 |
| | E.E. Theory 405, 406 | 4 | 4 |
| | Machine Design 3D37, 3D38 | 3 | 2 |
| | Engineering Materials Laboratory 3T31, 3T32 | 3 | 3 |
| | Industrial Accounting and Cost Finding 3A31 | 0 or 3 | 3 or 0 |
| | Fluid Mechanics CE6 | 3 or 0 | 0 or 3 |
| | Economic Organization 3A21 | 0 | 3 |
| | Total number of academic hours a term | 18 | 18 |

In addition, fifth- and sixth-term students must take the required Physical Training.

| TERMS | | *Seventh Term* | *Eighth Term* |
|---|---|---|---|
| 7 & 8 | Internal Combustion Engines 3P81 | 3 | 0 |
| 37 HOURS | Steam Power Plants 3P82 | 0 | 3 |
| | Mechanical Laboratory 3X40b, 3X41 | 4 | 4 |
| | Refrigeration and Air Conditioning 3P88 | 0 or 3 | 3 or 0 |
| | Elective or Option Courses (consult Director) | 11 or 9 | 9 or 11 |
| | Total number of academic hours a term | 18 or 19 | 19 or 18 |

In addition, seventh- and eighth-term students must take the required Physical Training.

Grand total for eight terms ..... 146 academic hours
(not including Military Science and Tactics and Physical Training)

# Eight-Term Curriculum (B.S. in A.E.)

In the curriculum given below the courses related to Administrative Engineering are printed in italics.

| | | HOURS | |
|---|---|---|---|
| TERMS | | *First Term* | *Second Term* |
| 1 & 2 | | | |
| 36 HOURS | See page 47 | 19 | 17 |
| | | *Third Term* | *Fourth Term* |
| TERMS | Analytic Geometry and Calculus 60c | 3 | 0 |
| 3 & 4 | Mechanics 3M21 | 5 | 0 |
| 36 HOURS | Strength of Materials 3M22 | 0 | 3 |
| | Kinematics, Recitations 3D25 | 3 or 0 | 0 or 3 |
| | Kinematics, Drawing 3D26 | 2 or 0 | 0 or 2 |
| | Engineering Materials 3T21, 3T22 | 3 | 3 |
| | Machine Tool Processes 3S23 | 0 | 2 |
| | Measuring Instruments 3S24 | 0 | 1 |
| | *Technical Reports* 3A33 | 2 or 0 | 0 or 2 |
| | *Industrial Statistics* 3A41 | 0 | 3 |
| | *Industrial Organization and Management* 3A35a | 0 or 3 | 3 or 0 |
| | *Economic Organization* 3A21 | 0 or 3 | 3 or 0 |
| | Total number of academic hours a term | 18 or 17 | 18 or 19 |

In addition to these courses, the student is required to take Military Science and Tactics and Physical Training.

| | | *Fifth Term* | *Sixth Term* |
|---|---|---|---|
| TERMS | Heat-Power 3P35, 3P36 | 3 | 3 |
| 5 & 6 | Machine Design, Recitations 3D37 | 3 | 0 |
| 36 HOURS | Machine Design Drawing 3D38 | 0 | 2 |
| | Engineering Materials Laboratory 3T31, 3T32 | 3 | 3 |
| | Electrical Engineering 405, 406 | 4 | 4 |
| | Fluid Mechanics CE6 | 0 | 3 |
| | *Industrial Accounting and Cost Finding* 3A31 | 3 | 0 |
| | *Principles of Cost Control* 3A47 | 0 | 3 |
| | *Industrial Relations* 3A49 | 2 | 0 |
| | Total number of academic hours a term | 18 | 18 |

In addition, the student must take the required Physical Training.

| | | *Seventh Term* | *Eighth Term* |
|---|---|---|---|
| TERMS | Internal Combustion Engines 3P81 | 3 | 0 |
| 7 & 8 | Refrigeration and Air Conditioning 3P88 | 0 | 3 |
| 38 HOURS | Mechanical Laboratory 3X40b, 3X41 | 4 | 4 |
| | *Industrial Engineering* 3I43 | 3 | 0 |
| | *Motion and Time Study* 3I54 | 0 | 2 |
| | *Standard Costs and Management Control* 3A54 | 3 | 0 |
| | *Corporation Finance* 3A34 or Economics 31 | 0 | 3 |
| | *Engineering Business Law* 3A43, 3A46 | 3 | 2 |
| | *Personnel Management in Industry* 3A42a | 0 | 3 |
| | Electives | 3 | 2 |
| | Total number of academic hours a term | 19 | 19 |

In addition, the student must take the required Physical Training.

Grand total for eight terms.....146 academic hours.
(not including Military Science and Tactics and Physical Training)

# School of Electrical Engineering

THE CURRICULA The School of Electrical Engineering offers a regular eight-term civilian curriculum leading to the degree of Bachelor of Electrical Engineering. Options are offered in Electrical Power and Electrical Communication which provide for specialization in these fields during the last four terms. However, the basic courses are the same in both options, so that the dangers of narrow specialization are avoided.

In normal times an eight-term curriculum leading to the degree of Bachelor of Science in Administrative Engineering, specializing in Electrical Engineering, is also offered. However, the reduced enrollment in this program now makes it impossible to offer the electrical courses regularly required in the last two terms, and this curriculum is not offered at present. Students particularly interested in Administrative Engineering may make special arrangements to substitute administrative courses for some of the technical courses required in the B.E.E. curriculum, and receive the B.S. in A.E. degree upon completion of the program.

Other curricula, of longer than eight terms duration, are normally offered, but deferment rules do not now regularly permit students to pursue programs of more than eight terms, and they are not listed at present. Students who are draft exempt, and who desire the longer programs, may make suitable individual arrangements by consulting the Director of the School and other officials concerned. Among these programs are:

(1) A ten-term curriculum, in which the student may receive both the degrees of Bachelor of Electrical Engineering and Bachelor of Science in Administrative Engineering.

(2) A ten-term curriculum, in which the student may receive the degree of Bachelor of Electrical Engineering at the end of the eighth term and the degree of Bachelor of Mechanical Engineering at the end of the tenth term.

(3) A ten-term curriculum, in which the student receives the degree of Bachelor of Electrical Engineering but supplements the regular program with two terms of additional cultural training, distributed throughout the ten terms of work.

(4) A twelve-term curriculum, in which the student may receive the degree of Bachelor of Arts at the end of the eighth term and the degree of Bachelor of Electrical Engineering at the end of the twelfth term.

THE FRESHMAN YEAR The first two terms of the eight-term program constitute the Freshman year. The curriculum of the Freshman year in Electrical Engineering is the same as that in Mechanical Engineering, so that transfer of a student between these two curricula may occur before the third term without loss of time. The Freshman curricula in the Schools of Chemical and Civil Engineering differ somewhat from the curriculum in Electrical Engineering, so that a change to or from one of these schools can seldom be made without loss of time or carrying extra work.

# Eight-Term Curriculum (B.E.E.)

| | | HOURS | |
|---|---|---|---|
| | | *First Term* | *Second Term* |
| TERMS | Analytic Geometry and Calculus Ma60a, 60b | 3 | 3 |
| 1 & 2 | General Physics 11, 12 | 4 | 4 |
| 36 HOURS | General Chemistry 1a, 2a | 4 | 2 |
| | Drawing and Descriptive Geometry 3C11 | 3 | 0 |
| | Mechanical Drafting 3C12 | 0 | 3 |
| | English NE1, NE2 | 3 | 3 |
| | Elementary Surveying 210A | 1 or 0 | 0 or 1 |
| | Metal Working 3S11 | 0 or 1 | 1 or 0 |
| | Casting Processes 3S15 | 0 | 2 |
| | Total number academic hours a term | 18 | 18 |

In addition to taking the above courses, all Freshmen must satisfy the University's requirements in Physical Training and in Military Science and Tactics.

| | | *Third Term* | *Fourth Term* |
|---|---|---|---|
| TERMS | Analytic Geometry and Calculus Math 60c | 3 | 0 |
| 3 & 4 | Engineering Mathematics 480 | 0 | 2 |
| 37 HOURS | Mechanics 3M21 | 5 | 0 |
| | Strength of Materials 3M22a | 0 | 3 |
| | Physics 21, 22 | 3 | 3 |
| | Engineering Materials 3T21 | 3 | 0 |
| | Economics 3A21, 3A22 or Ec1, Ec2 | 3 | 3 |
| | Machine Tool Processes, 3S23 | 2 | 0 |
| | Electric and Magnetic Circuits, Theory NEE3Th | 0 | 4 |
| | Electric and Magnetic Circuits, Lab. NEE3Lb | 0 | 1 |
| | Electrical Measurements NEE9 (2/5) | 0 | 2 |
| | Total number academic hours a term | 19 | 18 |

In addition to these courses, third and fourth term students are required to take Military Science and Tactics and Physical Training.

| | | *Fifth Term* | *Sixth Term* |
|---|---|---|---|
| | Electrical Power Option Only | | |
| TERMS | Elec. and Magnetic Circuits, Theory NEE4Th | 4 | 0 |
| 5 & 6 | Elec. and Magnetic Circuits, Lab. NEE4Lb | 1 | 0 |
| 36 HOURS | D-C Machinery and Storage Batteries, Theory NEE 12Th | 4 | 0 |
| | D-C Machinery and Storage Batteries, Lab. NEE12Lb | 1 | 0 |
| | AC Machinery, Theory NEE13Th | 0 | 4 |
| | AC Machinery, Lab. NEE13Lb | 0 | 1 |
| | Electrical Measurements NEE9 (3/5) | 0 | 3 |
| | Engineering Mathematics 481 | 2 | 0 |
| | Thermodynamics NME4a | 3 | 0 |
| | Heat Power, Theory NME3aTh | 0 | 2 |
| | Heat Power, Lab. NME3aLb | 0 | 1 |
| | Engineering Materials Laboratory 3T31 | 3 | 0 |
| | Kinematics 3D27 | 0 | 2 |
| | Fluid Mechanics NCE6 | 0 | 3 |
| | Contracts and Specifications NGE5 | 0 | 2 |
| | Total number academic hours a term | 18 | 18 |

In addition, fifth and sixth term students must take the required Physical Training.

| | | *Seventh Term* | *Eighth Term* |
|---|---|---|---|
| TERMS 7 & 8 37 HOURS | Advanced A-C Machinery 421 | 3 or 0 | 0 or 3 |
| | Electrical Insulation and High Voltage Practice 422 | 0 | 3 |
| | Electric Circuits 423, 424 | 2 | 2 |
| | Electrical Engineering Lab. NEE15 | 3 | 0 |
| | Electron Tubes and Circuits NEE5, 6 | 2 | 4 |
| | Electric Power Transmission 463 | 3 or 0 | 0 or 3 |
| | Electrical Power Plants 441 | 0 or 3 | 3 or 0 |
| | Electrical Design NEE14 | 0 or 3 | 3 or 0 |
| | Machine Design 3D37 | 3 | 0 |
| | Electives | 3 | 3 |
| | Total number academic hours a term | 19 | 18 |

In addition, seventh- and eighth-term students must take the required Physical Training.

Grand total for eight terms ..... 146 academic hours
(not including Military Science and Tactics and Physical Training)

## Electrical Communication Option Only

| | | HOURS *Fifth Term* | *Sixth Term* |
|---|---|---|---|
| TERMS 5 & 6 36 HOURS | Electric and Magnetic Circuits, Theory NEE4Th | 4 | 0 |
| | Electric and Magnetic Circuits, Lab. NEE4Lb | 1 | 0 |
| | D-C Machinery and Storage Batteries, Theory NEE 12aTh | 2 | 0 |
| | D-C Machinery and Storage Batteries, Lab. NEE12aLb | 1 | 0 |
| | A-C Machinery, Theory NEE13aTh | 0 | 3 |
| | A-C Machinery, Lab. NEE13aLb | 0 | 1 |
| | Electrical Measurements NEE9 (3/5) | 0 | 3 |
| | Electron Tubes and Circuits NEE5b, 6b | 2 | 3 |
| | Engineering Mathematics 481 | 2 | 0 |
| | Thermodynamics NME4a | 3 | 0 |
| | Heat Power, Theory NME3aTh | 0 | 2 |
| | Heat Power, Lab. NME3aLb | 0 | 1 |
| | Engineering Materials Laboratory, 3T31 | 3 | 0 |
| | Kinematics 3D27 | 0 | 2 |
| | Fluid Mechanics NCE6 | 0 | 3 |
| | Total number academic hours a term | 18 | 18 |

In addition, fifth and sixth term students must take the required Physical Training.

| | | *Seventh Term* | *Eighth Term* |
|---|---|---|---|
| TERMS 7 & 8 37 HOURS | Electrical Insulation and High Voltage Practice 422 | 0 | 3 |
| | Electric Circuits 423, 424 | 2 | 2 |
| | Electrical Engineering Lab. NEE15 | 3 | 0 |
| | High Frequency Circuits, Theory NEE7Th, 8Th | 3 | 3 |
| | High Frequency Circuits, Lab. NEE7Lb, 8Lb | 2 | 2 |
| | Communication Laboratory 457, 458 | 1 | 1 |
| | Communication Networks, 453, 454 | 2 | 2 |
| | Electrical Design NEE14a | 0 | 2 |
| | Machine Design 3D37 | 3 | 0 |
| | Electives | 3 | 3 |
| | Total number academic hours a term | 19 | 18 |

In addition, seventh- and eighth-term students must take the required Physical Training.

Grand total for eight terms ..... 146 hours
(not including Military Science and Tactics and Physical Training)

## Special Substitutions

A student in either the Communication or Power Option who has completed the first three terms of the regular eight-term curriculum with a superior record and with excellent grades in Mathematics, Physics, and Mechanics, may, if his class adviser approves, substitute a group of courses in Physics or other sciences such as Mathematics, Chemistry, or Economics for certain courses of instruction normally required in the last five terms, as follows:

| | |
|---|---|
| Economics 3A22 or Ec. 2 | 3 |
| Kinematics 3D27 | 2 |
| Machine Design 3D37 | 3 |
| Contracts and Specifications NGE5 | 2 |

The above substitutions are permitted only if the student fully utilizes, in the special field, all available elective hours.

Permission to continue these substitutions may be withdrawn at any time if the student's work is not entirely satisfactory.

## Elective Courses

A student of the School of Electrical Engineering may elect courses of instruction offered by the School of Electrical Engineering or by other schools or departments of the University, provided he has a sufficient number of elective hours available, has the necessary prerequisites, and secures the approval of his class adviser.

Courses of instruction given in the School of Electrical Engineering and open to election by students are indicated by title, number, and credit hours a term in the following list.

| | |
|---|---|
| Advanced A-C. Machinery 421 | 3 |
| Electrical Insulation and High Voltage Practice 422 | 3 |
| Electrical Power Plants 441 | 3 |
| Electric Power Transmission 463 | 3 |
| Communication Networks 453, 454 | 2 |
| Illumination 465, 466 | 2 |
| Engineering Mathematics 480, 481 | 2 |
| Operational Analysis 485, 486 | 3 |
| Special Electrical Engineering Problems 483 | 3 |
| Electron Tubes and Circuits NEE5, NEE5b | 2 |
| Electron Tubes and Circuits NEE6 | 4 |
| Electron Tubes and Circuits NEE6b | 3 |
| High Frequency Circuits, Theory NEE7Th, 8Th | 3 |
| High Frequency Circuits, Lab. NEE7Lb, 8Lb | 2 |
| Electrical Design NEE14 | 3 |

Students interested in following the V-12 curricula as closely as possible should elect the following courses in the seventh and eighth terms:

| | |
|---|---|
| General Psychology NPS1 | 3 |
| Industrial Organization 3A35 or NGE3 | 3 |

For courses given in other schools of the College of Engineering, the appropriate section of this Announcement should be consulted. For courses given in other colleges of the University, the Announcements of those colleges should be consulted.

# School of Chemical Engineering

TEN-TERM CURRICULUM

Civilian students now registered in the School of Chemical Engineering, who have completed five or more terms of the ten-term curriculum by November 1, 1943, will be awarded the degree of Bachelor of Chemical Engineering on the satisfactory completion of the ten terms of work. These students will not receive any degree on the completion of the first eight terms of the ten-term curriculum; except that, on recommendation by the Faculty of the College of Engineering, a student who is called to service in the armed forces of the United States after satisfactorily completing the first eight terms and before completing ten terms may be awarded the degree of Bachelor of Science in Chemical Engineering. Students who have completed less than five terms of the curriculum on November 1, 1943, or students entering on or after that date, will receive the degree of Bachelor of Science in Chemical Engineering on the satisfactory completion of eight terms of the prescribed eight-term curriculum. It is understood that the University reserves the right to discontinue the eight-term curriculum and the degree of Bachelor of Science at any time.

Here follows an outline of the regular ten-term curriculum in Chemical Engineering:

## Ten-Term Curriculum (B.Chem.E.)

| | | | HOURS | |
|---|---|---|---|---|
| | | | *First Term* | *Second Term* |
| TERMS 1 & 2 | Introductory Inorganic Chemistry | Chemistry 110 a,b | 3 | 2 |
| | Inorganic Chemistry Laboratory | Chemistry 115 | 3 | 0 |
| | Introductory Qualitative Analysis | Chemistry 203 | 0 | 5 |
| | Analytic Geometry and Calculus | Mathematics 60a, b | 3 | 3 |
| | English | English 2a, b | 3 | 3 |
| | Introductory Experimental Physics | Physics, 11, 12 | 4 | 4 |
| | Drawing | M.E. 3C14, 3C15 | 2 | 2 |

In addition to taking the above courses, all Freshmen must satisfy the University's requirements in Physical Training and in Military Science and Tactics.

| | | | *Third Term* | *Fourth Term* |
|---|---|---|---|---|
| TERMS 3 & 4 | Introductory Organic Chemistry | Chemistry 305a, b | 3 | 3 |
| | Organic Chemistry Laboratory | Chemistry 310a, b | 3 | 3 |
| | Introductory Quantitative Analysis | Chemistry 220 | 3 | 0 |
| | Quantitative Analysis Laboratory | Chemistry 221 | 3 | 0 |
| | Elementary Mineralogy | Geology 311 | 0 | 0 or 3 |
| | General Physics | Physics 21, 22 | 3 | 3 |
| | German | German 1b, c | 3 | 3 |
| | Calculus and Differential Equations | Mathematics 60c, d | 3 | 3 |

In addition to these courses, third- and fourth-term students are required to take Military Science and Tactics and Physical Training.

| | | | *Fifth Term* | *Sixth Term* |
|---|---|---|---|---|
| TERMS 5 & 6 | Introductory Physical Chemistry | Chemistry 405a, b | 3 | 3 |
| | Physical Chemistry Laboratory | Chemistry 410a, b | 3 | 3 |
| | Introductory Chemical Microscopy | Chem. E. 530 | 0 or 3 | 3 or 0 |
| | Elementary Mineralogy | Geology 311 | 3 or 0 | 0 |
| | Gas and Fuel Analysis | Chemistry 250 | 0 or 3 | 0 |
| | Mechanics | M.E. 3M21 | 5 | 0 |
| | Strength of Materials | M.E. 3M22a, b | 0 | 5 |
| | Chemical Engineering Technology | Chem. E. 701a, b | 2 | 2 |
| | Materials of Construction | Chem. E. 755a, b | 2 | 2 |

In addition, fifth- and sixth-term students must take the required Physical Training.

| | | | *Seventh Term* | *Eighth Term* |
|---|---|---|---|---|
| TERMS 7 & 8 | Unit Operations of Chemical Engineering | Chem. Eng. 705a, b | 3 | 3 |
| | Chemical Engineering Laboratory | Chem. E. 710a, b | 2 | 2 |
| | Advanced Physical Chemistry | Chemistry 420a | 3 | 0 |
| | Special Topics in Chemistry | Chem. E. 910 | 1 | 0 |
| | Heat-Power Engineering | M.E. 3P35 | 3 | 0 |
| | Heat-Power Engineering | M.E. 3P36 | 0 | 3 |
| | Engineering Materials Laboratory | M.E. 3T31 | 3 | 0 |
| | Mechanical Laboratory | M.E. 3X40a | 0 | 3 |
| | Chemical Engineering Economics | M.E. 3A53 | 3 or 0 | 0 |
| | Electives | | 0 or 3 | 6 |

In addition, seventh- and eighth-term students must take the required Physical Training.

| | | | *Ninth Term* | *Tenth Term* |
|---|---|---|---|---|
| TERMS 9 & 10 | Electrical Engineering | EE 407 | 4 | 0 |
| | Electrical Engineering | EE 408 | 0 | 4 |
| | Chemical Equipment Design | Chem. E. 780 | 2 | 2 |
| | Chemical Plant Design | Chem. E. 730 | 3 | 3 |
| | Chemical Engineering Computations | Chem.E. 740 | 2 | 2 |
| | Chemical Engineering Economics | M.E. 3A53 | 0 or 3 | 0 |
| | Electives (hours a term variable) | | 3 or 6 | 8 |

Students who present two or three units of German at entrance may not take the first term of German 1b for credit. Students who present three units of German may, on the recommendation of the Department of German, substitute German 8 for the second term of German 1b. The equivalent number of hours of electives will be substituted for the first term of German 1b, in the above cases.

Elective courses may be taken in any college of the University. The selection must be approved by the student's adviser.

## Eight-Term Curriculum (B.S. in Chem. E.)

| | | | HOURS *First Term* | *Second Term* |
|---|---|---|---|---|
| TERMS 1 & 2 38 HOURS | Introductory Inorganic Chemistry | Chemistry 110a, b | 3 | 3 |
| | Inorganic Chemistry Laboratory | Chemistry 115 | 3 | 0 |
| | Introductory Qualitative Analysis | Chemistry 203 | 0 | 5 |
| | Introductory Experimental Physics | Physics 11, 12 | 4 | 4 |
| | Analytic Geometry and Calculus | Mathematics 60a, b | 3 | 3 |
| | Drawing | M.E. 3C14, 3C15 | 2 | 2 |
| | English | English 2a, b | 3 | 3 |
| | Total number academic hours a term | | 18 | 20 |

In addition to taking the above courses, all Freshmen must satisfy the University's requirements in Physical Training and in Military Science and Tactics.

| | | | *Third Term* | *Fourth Term* |
|---|---|---|---|---|
| TERMS 3 & 4 38 HOURS | Introductory Organic Chemistry | Chemistry 305a, b | 3 | 3 |
| | Organic Chemistry Lab | Chemistry 310a, b | 3 | 3 |
| | Integral Calculus | Mathematics 60c | 3 | 0 |
| | Introductory Quantitative Analysis | Chemistry 220 | 3 | 0 |
| | Quantitative Analysis Lab | Chemistry 221 | 3 | 0 |
| | Introductory Physical Chemistry | Chemistry 405a | 0 | 3 |
| | Physical Chemistry Lab | Chemistry 410a | 0 | 3 |
| | Chemical Eng'g Stoichiometry | Chem.E. 745 | 2 | 0 |
| | General Physics | Physics 21, 22 | 3 | 3 |
| | Mechanics | M.E. 3M25 | 0 | 3 |
| | Total number academic hours a term | | 20 | 18 |

In addition to these courses, third- and fourth-term students are required to take Military Science and Tactics and Physical Training.

| | | | *Fifth Term* | *Sixth Term* |
|---|---|---|---|---|
| TERMS 5 & 6 36 HOURS | Introductory Physical Chemistry | Chemistry 405b | 3 | 0 |
| | Physical Chemistry Lab | Chemistry 410b | 3 | 0 |
| | Mechanics | M.E. 3M26, 3M27 | 3 | 3 |
| | Unit Operations of Chem. Engineering | Chem.E. 705a, b | 3 | 3 |
| | Chemical Eng'g Lab | Chem.E. 710a, b | 2 | 2 |
| | Heat-Power Engineering | M.E. 3P35 | 0 | 3 |
| | Introductory Chemical Microscopy | Chem. E. 530 | 0 | 3 |
| | Chemical Engineering Technology | Chem.E. 701a, b | 2 | 2 |
| | Materials of Construction | Chem.E. 755a, b | 2 | 2 |
| | Total number academic hours a term | | 18 | 18 |

In addition, fifth- and sixth-term students must take the required Physical Training.

| | | | *Seventh Term* | *Eighth Term* |
|---|---|---|---|---|
| TERMS 7 & 8 37 HOURS | Chemical Plant Design | Chem.E. 730a, b | 3 | 3 |
| | Electrical Engineering | EE 407, 408 | 4 | 4 |
| | Engineering Materials Laboratory | 3T31 | 3 | 0 |
| | Mechanical Laboratory | 3X40a | 0 | 3 |
| | Chemical Eng'g Computations | Chem.E. 740 | 2 | 2 |
| | Chemical Thermodynamics | Chemistry 420a | 3 | 0 |
| | Chemical Equipment Design | Chem.E. 780a, b | 2 | 2 |
| | Chemical Engineering Economics | M.E. 3A53 | 0 | 3 |
| | Heat-Power Engineering | M.E. 3P36 | 3 | 0 |
| | Total number academic hours a term | | 20 | 17 |

In addition, seventh- and eighth-term students must take the required Physical Training.

Grand total for eight terms ..... 149 academic hours

(not including Military Science and Physical Training)

If, in the opinion of the faculty of the School of Chemical Engineering, a student's general record is unsatisfactory, the student will be refused permission to continue his work for the degree of B.Chem.E., even though he has met the minimum requirements in respect to the number of hours of work passed and the grades in these hours.

## OPTIONS IN CHEMICAL ENGINEERING

A student in Chemical Engineering may, by suitable selection of his elective courses, obtain specialized and intensive training in any one of several optional fields. The completion of an option in one of these specialized fields is not required. The student may, if he so desires, arrange his elective work to provide a cultural background not afforded by courses within the scope of the strictly professional field. The selection of electives must be approved by the class adviser.

The elective courses are normally taken in the fourth and fifth years, although in some instances it may be of advantage to include some of them in the third year.

The available options and the recommended courses in each are listed below. The courses of primary importance are indicated by an asterisk.

### ADMINISTRATIVE ENGINEERING

| | |
|---|---|
| *Engineering Business Law or | M.E. 3A43 |
| *Engineering Law | C.E. 290 |
| *Engineering Economy | M.E. 3I48 |
| Corporation Finance | Economics 31 |
| *Industrial Relations | M.E. 3A49 |
| *Public Speaking | 1 |
| Industrial Statistics | M.E. 3A41 |
| Principles of Cost Control | M.E. 3A47 |

### ORGANIC CHEMISTRY

| | |
|---|---|
| *Advanced Organic Chemistry | Chemistry 315 |
| *Identification of Organic Compounds | Chemistry 340 |
| *Special Topics in Organic Chemistry | Chemistry 325 |
| Biochemical Aspects of Organic Chemistry | Chemistry 345 |
| Physical Aspects of Organic Chemistry | Chemistry 335 |
| Advanced Organic Chemistry Laboratory | Chemistry 320 |
| *Food Technology | Chem.E. 720a, b |
| Synthetic Resins and Plastics | Chem.E. 715 |

### PHYSICS

| | |
|---|---|
| *Modern Physics | Physics 41, 42 |
| *Special Topics in Physics (Laboratory) | Physics 315 |
| *Advanced Laboratory Practice | Physics 105 |
| Mechanics | Physics 111 |
| Properties of Matter | Physics 112 |
| Electricity and Magnetism | Physics 121 |
| Electricity and Magnetism | Physics 122 |
| Light | Physics 132 |
| Heat | Physics 142 |
| Wave Motion and Sound | Physics 162 |
| Special Topics Laboratory | Physics 320c, d or f |

### METALLURGY AND METALLOGRAPHY

| | |
|---|---|
| *Metal Processing | M.E. 3S11 |
| *Introductory Metallography | Chem.E. 545 |
| *Advanced Metallography | Chem.E. 550 |
| *Advanced Inorganic Chemistry | Chemistry 130A |
| *Electrochemistry | Chemistry 450 |
| Phase Rule | Chemistry 425 |
| Properties of Matter | Physics 112 |
| Advanced Laboratory Practice | Physics 105 |

SANITARY ENGINEERING

| | |
|---|---|
| *Sanitary Biology | C.E. 250 |
| *Sewerage and Sewage Treatment | C.E. 252 |
| Treatment of Water | C.E. 253A |
| *Treatment of Wastes | C.E. 255 |
| *Sanitary Biology | C.E. 251 |
| Water and Sewage Analysis | C.E. 258 |
| Laboratory Course for Graduates | C.E. 259 |

PHYSICAL CHEMISTRY

| | |
|---|---|
| *Chemistry of Solids | Chemistry 435 |
| *Applications of Phase Rule | Chemistry 425 |
| *Introductory Electrochemistry | Chemistry 445 |
| *Colloid Chemistry | Chemistry 430 |
| *Applied Electrochemistry | Chemistry 450 |
| *Thermodynamics | Chemistry 470 |
| Advanced Inorganic Chemistry | Chemistry 130 |

FOODSTUFFS

| | |
|---|---|
| *Food Technology | Chem.E. 720a, b |
| Advanced Organic Chemistry | Chemistry 315 |
| *Biochemical Aspects of Organic Chemistry | Chemistry 345 |
| Sewerage and Sewage Treatment | C.E. 252 |
| *General Bacteriology | Bacteriology 1 |
| *Applied Bacteriology | Bacteriology 103 |
| Treatment of Wastes | C.E. 255 |

# Description of Courses

The courses listed in the preceding curricula are described in the following sections of this Announcement. If the first letter of the course number is N, the course is conducted in accordance with the requirements of the Navy V-12 program and is described in the section devoted to Navy courses. Courses not included in the V-12 program are described under the heading of the school or college in which the course is offered. Courses in Chemistry, English, Mathematics, Physics, and certain courses in Economics, are offered by the College of Arts and Sciences. Courses in Military Science and Tactics and Physical Training, under the direct supervision of the University as a whole, are listed in a general section.

For courses in other colleges not described here, to be taken as electives, see the Announcement of the appropriate college.

## CIVIL ENGINEERING

### ASTRONOMY

182. *The Elements of Field Astronomy.* Required of Civil Engineering sophomores. Second term. Credit two hours. Prerequisite, Surveying 210 (or Astronomy 180 and Mathematics 3). The determination of time, latitude, longitude, and azimuth by observations on the sun and stars using a surveyor's transit and a watch. Textbooks: *Textbook of Practical Astronomy* by Nassau and *Determination of Azimuth, Time, and Latitude* by Boothroyd. One one-hour recitation and one two-hour laboratory period a week, some of the laboratory periods being in the late afternoon and at night for observations on sun and stars. Professor SHAW.

183. *Navigation and Nautical Astronomy.* Elective. Either term. Credit three hours. Prerequisite, Mathematics 3. Position of a ship or airplane by dead reckoning and by astronomical observation, with laboratory exercises, using sextant to determine time, latitude, and longitude. Students who already have two hours credit for Course 182 will get one hour additional credit upon completion of the extra work necessary to obtain credit for Course 183. Civil Engineering sophomores may take this course instead of Course 182 and count the extra hour credit as a Civil Engineering Elective. Textbooks: *The Essentials of Modern Navigation*, by Wylie and *Textbook of Practical Astronomy* by Nassau. Each student should have access to a copy of the *American Nautical Almanac* for the year. Lectures and recitations M at 10 with two two-hour laboratory periods a week to be arranged. Some of the laboratory and recitation periods during several weeks of the term are used for sextant observations of the sun during the day and of the moon, stars, and planets at night. This course should be of special interest to those who contemplate becoming aviators or navigators. Professor SHAW.

186. *Geodetic Astronomy.* Elective. Either term. Credit three hours. Prerequisites, Astronomy 182 and Advanced Surveying 211 (or Mathematics 4a and 4b and General Astronomy 187) or approved equivalents. The theory and practice of the precise determination of time, latitude,

longitude, and azimuth. Figure of the Earth and Isostacy will also be considered. Textbook: Hosmer's *Geodesy*, Second Edition. Lecture and discussion, one hour a week and evening observing at the Observatory together with the reduction of observations which will average about 5 hours a week throughout the term. The laboratory work may be spread throughout the year if it seems desirable to do so. Professor SHAW.

### DESCRIPTIVE GEOMETRY AND DRAWING

200. *Drawing*. First term. Credit three hours. Use of drawing instruments, free-hand lettering, titles, geometrical problems, simple orthographic projection, technical sketching. Textbook: *Technical Drawing*, Giesecke, Mitchell and Spencer. Assistant Professors JENKINS, PERRY, Associate Professor THATCHER, and Mr. SPRY.

201. *Drawing*. Second term. Credit three hours. Orthographic projection, sections, scale drawings, practical problems, tracing, blueprinting, conventional signs, topographic mapping, isometric drawing. Textbook: *Technical Drawing*, Giesecke, Mitchell and Spencer. Assistant Professors JENKINS, PERRY, Associate Professor THATCHER, and Mr. SPRY.

203. *Drawing*. Required of all sophomores in Civil Engineering. Any term. Credit two hours. Lettering, with practice in forming letters and combining them into appropriate titles; projections and intersections of practical problems; structural detailing and tracing; reading engineering drawings. Textbook: *Technical Drawing*, Giesecke, Mitchell and Spencer. Assistant Professors JENKINS and PERRY, Associate Professor THATCHER, and Mr. SPRY.

204. *Drawing*. Required of all Civil Engineering sophomores. Any term. Credit three hours.

Instruction and drill in the fundamental conceptions of descriptive geometry, including orthographic projection and representation of the point, line, and plane. A study of the sections, developments, and intersections of surfaces and solids with applications in practical problems. Textbook: Rowe's *Engineering Descriptive Geometry*. Assistant Professor JENKINS and Mr. SAAD.

205. *Advanced Drawing*. Elective. Juniors and seniors. Any term. Credit one to three hours. Perspective drawings, rendered in pencil, ink, and washes, of buildings, concrete bridges, dams, and other engineering works; building details of window frames, doors, stairs, and other simple units, to give the student some insight into detailing parts of plans, and further to familiarize him with reading working drawings. Problems in concrete, structural, topographical, highway, and sanitary drafting; engineering drawings, rendered in color, to enable the student to supplement ordinary working drawings with artistic representations so portrayed as to be readily intelligible to non-technical persons. Assistant Professor JENKINS.

N.D. 1. Drawing for first term naval students.
See Naval V-12 Program Announcement.

N.D. 2. Drawing for second term naval students. Assistant Professor JENKINS.
See Naval V-12 Program Announcement.

ORIENTATION

209. *Introductory Lectures.* Freshmen. Credit one hour. One lecture a week. This course of lectures is designed to introduce the first-year men to the various fields of civil engineering, and to demonstrate to them some of the simpler and more general methods of engineering construction. It is the purpose of the lectures to awaken the interest of the freshmen in their chosen profession through the aid of vivid description, of stimulating biography, and of personal experience. Not given during the emergency.

SURVEYING

210. *Elementary Surveying.* Required of freshmen in Civil Engineering. First term as assigned. Credit three hours. Use of steel tape, level, and transit; fundamental surveying methods; measurements of lines, angles, and differences of elevation; land surveying, areas and plotting. Textbook: Breed and Hosmer's *Elementary Surveying.* First term, one recitation and two field, computation, or mapping periods a week. Second term, three recitation periods a week for the first six weeks and three field, computation, or mapping periods a week during the remainder of the term. Professor UNDERWOOD, Assistant Professor LAWRENCE, and Mr. SPRY.

210-A. *Elementary Surveying.* Required of freshmen in Mechanical and Electrical Engineering. Either term. Credit one hour. Use of steel tape, level and transit. Fundamentals. Problems of particular interest to Mechanical and Electrical Engineering. Textbook: *Surveying,* Breed. One 2½-hour period a week. Professor UNDERWOOD, Assistant Professors LAWRENCE, CRANDALL, FERRY, and Mr. SPRY.

211. *Advanced Surveying.* Required of all freshmen in Civil Engineering. Any term. Credit three hours. Prerequisite, Elementary Surveying 210. City and mining surveying; surveys of the United States public lands; rectangular coordinate systems for cities and states; volumetric, topographic, hydrographic, and geodetic surveying; transit, stadia and plane table surveys; sextant; soundings, triangulation; base lines; precise and trigonometric leveling; elements of photographic surveying; map projections. Textbooks: Breed and Hosmer's *Elementary Surveying,* Vol. I, and *Higher Surveying,* Vol. II. Two recitations and one field period a week during the first half of the term, and three recitations a week during the remainder of the term. Professor UNDERWOOD, Assistant Professor LAWRENCE, and Mr. SPRY.

212. *Advanced Surveying.* For students in Landscape Architecture. Second term in alternate years. Not given in 1944–45. Credit two hours. Prerequisite Elementary Surveying 210 or 210-A. Profile leveling; cross-sectioning; earth-work; circular curves and spirals; vertical curves. Textbook: Breed and Hosmer's Vol. I, *Elementary Surveying.* Recitations, computation, and field work. Assistant Professor LAWRENCE.

213. *Summer Survey:* (Topographic, Hydrographic, and Geodetic Survey Camp.) Required of all Civil Engineering students, following the sophomore year. Credit four hours for course 213 and one hour for course 260-A. Prerequisite Advanced Surveying 211. Practical experience in surveying under field conditions. An extensive topographic survey with the transit

and stadia and the plane table, and a hydrographic survey of a portion of Cayuta Lake are executed, and field maps are made. Triangulation and precise leveling control the topographic and hydrographic work. A base line is measured with invar tapes. Solar observations for azimuth and time are made and results computed. Each student takes part in all branches of the work. Field and office work six days a week. Attendance for four weeks is required for course 213 (four hours credit) and one week for course 260-A (one hour credit; see page 70 for description of this course). Date of beginning of the camp will be announced in the second term. Professor UNDERWOOD, Assistant Professors LAWRENCE, PERRY, Associate Professor THATCHER, and Mr. SPRY.

Not given during the emergency.

213A. *Surveying.* Required of all Civil Engineering students in lieu of 213, Summer Surveying. Credit three hours. Prerequisite Advanced Surveying, 211. Practical experience in the field.

Professor UNDERWOOD and Assistant Professor LAWRENCE.

214. *Mapping.* Elective for upperclassmen and required for juniors in the Geodetic Engineering Option in Civil Engineering. First term. Credit two hours. The construction of a final topographic map of the area covered by the field work of Course 213 during the preceding summer. The field sheets are combined for this purpose, reduced in scale from 1:4800 to 1:12000, and reproduced, using the triangulation system as a base for the work. Lectures and drawing. Two laboratory periods a week. Professor UNDERWOOD.

214-A. *Topographic Surveying.* Required for juniors taking the Geodetic Engineering Option in Civil Engineering, elective for others. First term. Credit one hour. Prerequisite courses 211 and 213. Methods of making topographic surveys for mapping to a large scale. The use of the plane table in such surveys. Solutions of the three-point problem; two-point problem; location of details by direction and distance. Field work and mapping. One field or drawing period a week. Professor UNDERWOOD.

215. *Problems in the Adjustment of Observations.* Elective for upperclassmen and required for seniors taking the Geodetic Engineering Option in Civil Engineering. First term. Credit one hour. Prerequisite, course 213. A series of examples in the adjustment of typical surveying work such as leveling, direct measurement of lines and angles, and simple triangulation figures, using the methods of least squares. Lectures and problems. Professor UNDERWOOD.

216. *Least Squares: Adjustment of Observations.* Required of seniors taking the Geodetic Engineering Option in Civil Engineering, elective for others. Any term. Credit two hours. Prerequisites, Calculus and Physics. The course is designed for students who have experimental investigations in view. Applications are made to problems in physics, astronomy, mechanics, hydraulics, surveying, etc., with some attention given to the derivation of empirical formulae. Textbook: Leland's *Practical Least Squares.* Two recitations and lectures a week, as may be arranged. Professor UNDERWOOD.

217. *Advanced Topographic Surveying.* Elective. Upperclassmen. Second term. Credit two hours. Prerequisite, course 213. Economics of surveying

methods. Surveys for special purposes, such as extensive construction work, storage and distribution of water for irrigation; earthwork on a large scale, lines of communication, topographic reconnaissance, etc.; photographic surveying. Lectures, recitations, and assigned readings. Two hours a week. Professor UNDERWOOD.

218. *Geodesy and Geodetic Laboratory.* Elective for upperclassmen and required for seniors taking the Geodetic Engineering Option in Civil Engineering. Any term. Credit three hours. Prerequisites, courses 182 and 211. A course for the consideration of special problems in geodetic work. Precise leveling, deflection of the plumb line, figure of the earth, use and investigation of geodetic instruments and apparatus such as circles, levels, micrometer microscopes, standards of length, thermometers, pendulums, magnetic apparatus, etc. Subject to arrangement to meet the special needs of students. Lectures, reading, discussions, and laboratory work. Three periods a week. Professor UNDERWOOD.

219. *Photographic and Aerial Surveying.* Elective for upperclassmen and required for seniors taking the Geodetic Engineering Option in Civil Engineering. Any term. Credit three hours. Prerequisite, Advanced Surveying 211. The principles of photographic surveying; surveys with camera stations on the ground, including stereoscopic methods; aerial surveys and making of maps from such surveys; ground control. Recitations, lectures, and collateral reading. Three hours a week. Professor UNDERWOOD.

For *Research in Geodetic Engineering*, see Course 297i.

## MECHANICS OF ENGINEERING

220. *Mechanics of Engineering.* Required of all Civil Engineering sophomores. Any term. Credit five hours. Prerequisite course, Mathematics 55b. (See Course 220-B below.) Statics of a material point and of rigid bodies and structures by algebraic and by graphic methods of analysis; chains and cords; centers of gravity; moments of inertia; kinetics and dynamics of a material particle; centrifugal and centripetal forces; dynamics of collections of material particles forming rigid bodies; pendulums; friction, work, power, measurement of power; the general theorem of work and energy applied to collections of rigid members forming machines; impact, impulse, and momentum. Emphasis is placed upon the theory as well as upon the use of consistent units and correct numerical work. Facility in the use of the slide rule is essential. Textbook: Seeley and Ensign, *Analytical Mechanics for Engineers*. Five recitations a week. Assistant Professors HOWELL, GIFFT, Mr. PRIEST, and Mr. UDALL.

220-B. *Mechanics Computations.* Required of Civil Engineering sophomores. Any term. Credit one hour. To be taken with Course 220. Devoted to the solution of problems related to the topics covered concurrently in Course 220. One computation period of two and one-half hours a week under instruction. Assistant Professors HOWELL, GIFFT, and Mr. PRIEST.

221. *Mechanics of Engineering.* Required of Civil Engineering sophomores. Any term. Credit four hours. Continuation of Mechanics 220. Prerequisite course, Mechanics 220. Mechanics of materials including stress and strain, tension, shearing, compression, torsion, flexure; elastic curves;

safe loads; columns; flexure of beams by semigraphic treatment. Review problems showing application of principles in Engineering Design. Textbook: George & Rettger, *Mechanics of Materials*. Four recitations a week. Assistant Professors HOWELL, GIFFT, and Mr. PRIEST.

221-A. *Mechanics Computation*. Required of Civil Engineering sophomores. Any term. Credit one hour. Courses 221 and 221-A are closely correlated and should be taken concurrently. One 2½-hour period a week. Assistant Professors HOWELL, GIFFT, and Mr. PRIEST.

222. *Advanced Mechanics*. Elective. Seniors and graduates. Any term. Credit three hours. Prerequisites, courses 220 and 221. Following a brief general review of fundamental topics in Mechanics of Materials, this course covers induced stresses; torsion, unsymmetrical bending; torsion of prisms of non-circular section; hoops; flat plates; localized stresses; theory of least work; internal work and its derivatives. Textbook: Seeley, *Advanced Mechanics of Materials*. Recitations, three hours a week. Assistant Professor HOWELL.

223. *Engineering Problems*. Required of Civil Engineering seniors. Either term. Credit two hours. Prerequisites, courses 220, 221, and 240. The object of this course is to provide a review involving additional practice in using the principles and methods of applied mechanics. A series of problems, such as occur in ordinary engineering practice, and covering a wide range of topics, is given out for solution. Computations and reports. Five hours a week. Assistant Professor HOWELL.

224-A. *Engineering Mathematics*. Elective. Seniors and graduates. Required of Civil Engineering seniors in the Structural Engineering Option. First term. Credit three hours. Prerequisite, Mathematics 55b. An elementary course in ordinary differential equations with applications to engineering problems. Trigonometry, calculus, and algebra are dealt with in so far as this is necessary for a clear understanding of the treatment of differential equations. The purpose of this course is to lay the foundation for the more advanced courses in engineering mathematics. Three recitations a week.

224-B. *Advanced Engineering Mathematics*. Elective. Seniors and graduates. Second term. Credit three hours. Prerequisite, Course 224-A. This course is an introduction to the mathematics used in the solution of advanced engineering problems. Special emphasis is given to partial differentiation. Fourier Series, line integrals, formation of partial differential equations, integration in form of infinite series of several of the partial differential equations arising in engineering problems, vector notation, conformal representation, determinants, theory of the complex variable, development of function into series, etc., are reviewed in so far as a knowledge of these is essential to the course.

224-C. *Advanced Differential Equations*. Elective for graduates only. First term. Credit three hours. Prerequisite, courses 224-A and 224-B or their equivalents. A systematic study of differential equations. Partial differential equations and their solutions are emphasized. Assistant Professor CUYKENDALL. Not given during the emergency.

224D. *Special Mathematical Topics.* Elective. Graduates only. Second term. Credit three hours. Prerequisites, courses 224-A and 224-B. The content of this course depends largely on the needs and interests of those enrolled. Generalized coordinates, vector analysis, and the calculus of variations are three subjects to be considered. Not given during the emergency.

228-A, B. *Applied Elasticity.* Elective for graduates. Open to qualified undergraduates. Throughout the year. Credit three hours each term. Three lectures a week. Prerequisites, 224-A, 224-B, or Mathematics 200 or 70. General theorems of the elastic solid, reciprocal theorem, sudden loading. Tension, flexure, and torsion of bars of arbitrary section. Castigliano's theorem with application to frames, rings loaded in and normal to plane, spiral and helical springs. Stress in thick cylinders and discs due to pressure, heating, and rotation. Beams on elastic foundations. Symmetrical deformation of thin tubes. Propagation of stress waves in bars.

In the second term the topics are chosen from: Thermal stress. Stress-analysis, stability, and vibration, of plates and shells. Vibration of beams. Professor GOODIER.

228-C. *Engineering Physics of Metals.* Elective. Primarily for graduate students. Second term. Credit three hours. An introduction to the physical basis of matter in relation to its elastic and plastic behavior. Topics for discussion include atomic basis of generalized Hooke's Law, atomic cohesive forces and potential troughs, the yield value, primary bonds, dipole and Van der Waal's forces, influence of temperature on elastic properties, thermoelastic basis of internal friction, experimental and theoretical strengths of crystals, distortion of the lattice, Smekal's criticism of Born's lattice theory of metals, evidence of submicroscopic structure, elementary concepts of the cooperative phenomena in metals. Assistant Professor CUYKENDALL. Not given during the emergency.

229-A. *Theory of Elastic Stability.* Elective for seniors and graduates. First term. Credit three hours. Prerequisite courses, 220, 221, 224-A, or equivalents. Mathematical analysis of the conditions under which columns, beams, rings, tubes, thin plates, and thin curved shells may fail by general or local buckling. Applications to mechanical, civil, naval, and aeronautical structures. Professor GOODIER. (Given only in alternate years. Not given in 1944–45.)

229-B. *Mechanics of Vibration.* Elective for seniors and graduates. First term. Credit three hours. Prerequisite, Course 224-A. The characteristic phenomena of mechanical vibrations encountered in engineering, and their quantitative investigation, illustrated by a group of typical vibrating systems. Representation of simple harmonic motion. Combination of several simultaneous motions. Simple cases of free and forced vibrations, with damping. Resonance. Principles of transmission and isolation of vibration. Systems of variable mass and variable elasticity. Vibrations of taut wires, bars, beams, rings, membranes, and plates. Relation of vibration and noise. Detection and measuring instruments. Examples of diagnosis and preventive measures. Professor GOODIER. (Given only in alternate years. To be given in 1944–45.)

MATERIALS OF CONSTRUCTION

225. *Materials of Construction.* Required of all Civil Engineering juniors. Either term. Credit three hours. Prerequisite Course 221. The materials studied are lime, cement, stone, brick, sand, timber, ores, cast iron, wrought iron, steel, and some of the minor metals and alloys. The chemical and physical properties, uses, methods of manufacture, methods of testing, and unit stresses of each material are considered, particular emphasis being laid on the points of importance to engineers. Three recitations a week. Professor SCOFIELD.

226. *Materials Laboratory.* Required of all Civil Engineering juniors. Either term. Credit three hours. Prerequisite course 221 and must be taken with or preceded by 280. Experimental determination of the properties of materials by mechanical tests. Study of testing machines (their theory, construction, and manipulation); calibration of testing machines and apparatus; commercial tests of iron and steel; tensile, compressive, torsional, shearing, and flexure tests of metal and various woods with stress-strain observations; tests of cement, concrete aggregate, concrete, plain and reinforced, and of road material and paving brick. The course is planned to supplement Course 225 with its study of the properties of materials by the actual handling of the materials and by observations of their behavior under stress. Laboratory work five hours a week. Professor SCOFIELD.

227. *Testing of Materials.* (*Laboratory.*) Given especially for students in the College of Architecture. Any term. Credit one hour. A brief course in laboratory methods comprising tests of beams and columns in steel, wood, and concrete. Professor SCOFIELD.

227-A. *Concrete and Concrete Materials.* Elective for seniors and graduates in Mechanical, Chemical, Electrical Engineering. Either term. Credit one hour. A brief course in the study of concrete and the materials entering into concrete. The course will consist of lectures and laboratory work. One 2½-hour period a week. Professor SCOFIELD.

For Research in Engineering Materials, see Course 297-b.

HYDRAULIC ENGINEERING

230. *Applied Hydrology.* Required of all Civil Engineering seniors. Either term. Credit two hours. Prerequisite, course 240. The term is devoted to the methods of making the preliminary investigations for a hydraulic development involving the use of a stream; general hydrology; water resources of a basin; methods of systematic stream gaging; stream characteristics; working up data; use of mass curves in storage studies; percolating waters; probably dependable draft, etc.; a study of the working conditions and fundamental data for designing conduits, distributing reservoirs. In the problems, applications of the text are made to particular localities, the topographic maps of drainage basins forming the bases of the problems. Students contemplating extensive election of courses in the hydraulics group should arrange to take this course the first term. Courses 231, 232, and 233 are elaborations of details in this course. Textbooks: Turneaure & Russell, *Public Water Supplies;* Hoyt & Grover, *River Discharge.* Two recitations a week. Professor DOTY.

231. *Hydraulic Construction.* Elective for seniors and graduates and required of Civil Engineering seniors in the Hydraulic Engineering Option. Second term. Credit three hours. This is a computing and designing course dealing with problems of water storage and the design and construction of dams by means of lengthy problems to be solved by graphical and analytical methods, and involving the economics of water storage at a given site; the design of a high masonry dam by Wegmann's Method and the tests for safety and stability of design, and the analysis of stresses and stability. Professor DOTY.

232. *Water Power.* Elective. Seniors and graduates. Either term. Credit three hours. Prerequisites, courses 230 and 240 or the equivalent. The subject matter of the course covers the technique of hydraulic turbines, the analysis of test data, a study of the adaptation of turbine types to working conditions, unsteady flow and surging in long conduits, governing, and the analysis of the power available at a low head millsite. Textbook: Mead's *Water Power Engineering.* Three lectures and recitations a week and the working of three lengthy problems during the term. Professor DOTY. (Not given 1944–45).

233. *Hydraulic Engineering.* Elective. Seniors and graduates. First term. Credit three hours. The theory of percolating water; ground water development; recent developments in soil technology and the design and construction of earthen dams and levees; theory of design of gravity and arch masonry dams and distribution of stresses in such structures; spillway design; preparation of dam sites; construction methods and plants. Lectures, recitations, and abstracting of references. Professor DOTY.

234. *Conservancy and Reclamation Problems.* Elective. Seniors and graduates. Any term. Credit three hours. Flood flow estimates; planning for and designing of flood protection structures, irrigation, and drainage works. The Miami Conservancy work will be the chief source of material for the course. Lectures, recitations, and abstracting of references. Professor DOTY.

236. *Water Power and Pumping Plants.* Elective. Seniors and graduates. Second term. Credit three hours. This is a computing and designing course devoted to the problems of designing and detailing power and pumping plants. Prerequisites, courses 230 and 232. Professor DOTY.

(For *Hydraulic Engineering Design*, see course 291c.)
(Not given 1944–45).

THEORETICAL AND EXPERIMENTAL HYDRAULICS

240. *Hydraulics.* Required of all Civil Engineering juniors. Either term. Credit four hours. Prerequisites, courses 220 and 221. Hydrostatic pressure; manometers; strength of pipes; stability of dams; immersion and flotation; flow of liquids through orifices, nozzles, Venturi meters, and pipes, and over weirs; time required to empty tanks and reservoirs; simple, compound, branching, and looping pipes; elementary power calculations in common pumping and fire protection problems; flow of water in open channels; pressure on stationary solids due to deviated flow. Elementary consideration of modern water wheels. Textbook: Schoder and Dawson's *Hydraulics.* Three recitations and one laboratory period a week. About ten of the recita-

tion periods are utilized for demonstration lectures. Professor SCHODER and Assistant Professor BOGEMA.

241. *Advanced Hydraulics.* Elective for seniors and graduates. Second term. Credit three hours. Prerequisite, course 240. Topics selected from the following list are taken up, subject to changes to suit group requirements: stability of flotation; barometric levelling; flow over weirs and dams, free and submerged; backwaters and non-uniform flow in open channels; the hydraulic jump; water hammers; surges in pipes and canals; flow of liquids and gases in pipes, hydraulic similitude and flow in models; some introductory elements of hydrodynamics; impulse wheels and turbines; centrifugal pumps. Lectures, recitations, and problems. Three hours a week. Professor SCHODER.

242. *Hydraulic Measurements.* Elective for seniors and graduates and required for seniors in the Hydraulic Engineering Option in Civil Engineering. First term. Credit three hours. Prerequisite, course 240. Experimental studies involving usually (as time permits) current meters and floats in canal or river; Pitot tubes in pipes; water meters; weirs; the hydraulic jump; special features of orifices, nozzles, Venturi meters, pipes; model studies; such other occasional experimental measurements as opportunity offers in the laboratory or in the neighborhood of Ithaca; the determination of efficiency, capacity, and characteristics of hydraulic machinery by tests. Three periods a week in laboratory or computing room. Professor SCHODER. N.C.E. 6—Fluid Mechanics—for V-12 students. See page 107.

(For *Engineering Research in Hydraulics*, see course 297c.)

### MUNICIPAL AND SANITARY ENGINEERING

250. *Sanitary Biology.* Required in the Sanitary Engineering Option in Civil Engineering. Elective for Chemical Engineers and for juniors, seniors, and graduates in Civil Engineering. First term. Credit three hours. The course is designed to familiarize the student with the use of the microscope, preparation of media, bacteriological analyses of water, sewage, sewage effluents, and sewage sludge; the preparation and use of stains; disinfection of sewage and of swimming pools. Textbook: Buchanan's *Bacteriology.* One recitation and two laboratories a week. Professor WALKER.

251. *Sanitary Biology.* Required in the Sanitary Engineer Option in Civil Engineering. Elective for Chemical Engineers and for juniors, seniors, and graduates in Civil Engineering. Second term. Credit two hours. The subject matter covered in the course includes the collection, identification, and control of the various forms of plant and animal life most prevalent in water supplies, and associated with sewage wastes and industrial waste-polluted streams. Consideration is given to the making of biological counts and to the use of biological forms of life as indices of pollution. Various references and texts are used in the course. One recitation or lecture and one laboratory a week. Professor WALKER.

252. *Sewerage and Sewage Treatment.* Required of all juniors or seniors in Civil Engineering. Elective for Chemical Engineering students and for others having prerequisite training. Either term. Credit three hours. Prerequisite, course 240. The design of sanitary and of storm sewers, and the

methods of treating sewage are considered in the recitations; and in the computing period, problems are assigned dealing with design and operation and with subject matter considered in recitation and class-room work. The problems are largely of the nature of separate designs. Textbook: Metcalf and Eddy's, *Sewerage and Sewage Treatment.* Two recitations and one computing period a week. Professor WALKER and Assistant Professor GIFFT.

253. *Control and Treatment of Water Supplies.* Required in the Sanitary Engineering Option. Elective for other seniors and graduates. Second term. Credit three hours. Prerequisite, course 253A. This course comprises a comprehensive study of the general principles and methods involved in furnishing safe water supplies of satisfactory quality. The topics studied include the character of surface and underground water supplies; inspection of sources; relation of communicable diseases to water supplies; standards of quality and examination procedures to determine quality and safety of supplies; water treatment methods including coagulation, sedimentation, aeration, slow and rapid sand filtration, tastes and odor control, softening and iron removal, corrosion control, sterilization, and miscellaneous treatment methods. Also some study of design and operation of water treatment plants is included. Two recitations and one computation period a week. Professors STANLEY and WALKER.

253-A. *Water Supply.* This course has been consolidated with N.C.E. 14, which see later.

254. *Sewerage Works.* Required in the Sanitary Engineering Option in Civil Engineering. Elective for other seniors and graduates. First term. Credit three hours. Prerequisite, course 252. A comprehensive study of principles and methods involved in the design, construction, and operation of sewers and sewerage treatment works, including reference to existing typical plants. In general, the study includes the determination of capacity and design of sewers; the disposal of sewage by dilution or broad irrigation; stream pollution and self-purification; sewage treatment methods, including preparatory devices, sedimentation, chemical precipitation, intermittent sand, and trickling filters, activated sludge, sludge digestion, sludge dewatering and incineration, and miscellaneous treatment methods. Textbook: Metcalf and Eddy, *American Sewerage Practice, Vol. III, Disposal of Sewage.* Two recitations and one computation period a week. Professors STANLEY and WALKER.

255. *Treatment of Wastes.* Required for seniors in the Sanitary Engineering Option in Civil Engineering. Elective for other seniors and graduates in Civil Engineering and for Chemical Engineers. First term. Credit three hours. Prerequisite, course 252. The treatment of municipal and industrial wastes such as garbage, and the wastes from tanneries, packing-houses, mines, canning factories, textile mills, paper and pulp mills, creameries, cheese factories, condensaries, breweries, sugar refineries, etc. Flow or process charts are used to show the general character of the waste, and methods of treatment applicable are considered. Special attention is given to experimental studies of waste treatment, and to plant-scale treatment. Numerous references, bulletins, reports. Three lectures or recitations a week. Professor WALKER.

256. *Municipal Administrative Engineering.* Required for Civil Engineering seniors in the B.S. in A.E. Course. Elective for other seniors and graduates. First term. Credit three hours. A study of civic government and the relationships between the civil engineer in public service and various city, county, state, federal, and special governmental bodies, with which he may become associated; general principles involved in the operation and administration of the public works department and the effect of these on the activities of the engineer; methods of financing governmental operations, including bond issues, sinking funds, special assessments, service and rental charges. Three lectures or recitation periods a week. Professor STANLEY. Not given during the emergency.

256-A. *Public Health Engineering.* Elective for seniors and graduates. Second term. Credit three hours. A study of the place of the engineer in public health work. Organization and operation of Boards of Health; mosquito abatement, epidemiology and vital statistics, public health laws, and the sanitary code. Three lecture or recitation periods a week. Professor STANLEY. Not given during the emergency.

256-B. *Rural Sanitation.* Elective for juniors, seniors, and graduates. Second term. Credit two hours. A course dealing with the sanitation of rural areas, trailer, construction, military, recreational, and other camps, summer hotels, and swimming pools; the inspection of municipal or public water supplies, sewerage systems; and sewage treatment plants, garbage treatment plants, restaurants and the rating of water supply and milk sheds. Attention is given to water supply, sewage and garbage disposal, and to the problem of milk sanitation. Lectures, reports, and recitations. Two periods a week. Professor WALKER.

258. *Water and Sewage Analysis.* Required of juniors in the Sanitary Engineering Option in Civil Engineering. Elective for other juniors and seniors. First term. Credit two hours. The purpose of the course is to acquaint the student with the standard procedures followed in making physical and chemical analyses of water and of sewage. Textbooks: Standard Methods of Water Analysis, A.P.H.A., Water and Sewage Analysis, Eldridge, Theroux, and Mallman. Two laboratory periods a week with lectures, recitations, and laboratory work. Professor WALKER and Assistant.

259. *A Laboratory Course for Graduates.* Hours to be arranged. A course devoted to some problem of water or sewage or trade waste, such as the operation of a water filtration plant, a sewage disposal plant, the detection, measurement, and treatment of trade wastes, the value of disinfection, etc. Professor WALKER.

(For *Sanitary Engineering Design and Research*, see courses 291d and 297d.)

TRANSPORTATION ENGINEERING

260-A. *Location Surveying.* Required of all Civil Engineering students as a part of Summer Survey Camp, following the sophomore year. Credit one hour. Taken concurrently with course 213 (Four hours credit. See description on page 61.) Each section is required to make complete preliminary and location surveys for a line two or three miles long. In this work the section is divided into level, transit, topography, and cross-section parties,

as the different phases of the work are encountered. Finally structure and right of way surveys are made. The assignments of the men are changed every day so that each student receives practice in the various kinds of field work. Attendance at summer camp for one week is required. Date of beginning will be announced in the second term. Professor BARNES, Associate Professor THATCHER, Assistant Professor PERRY, and Mr. SPRY. Not given during the emergency.

260-B. *Route Surveying and Drawing.* Required of all Civil Engineering sophomores. Second term. Credit three hours. Prerequisite, Advanced Surveying 211. The recitations cover the theory of simple, transition, and vertical curves, and earthwork computations; with applications to practical problems for purposes of illustration. The field periods take up about two-thirds of the term and are devoted to computing, laying out and checking simple, transition, and vertical curves. Each section is divided into parties of three so that each student obtains more individual instruction, more practice in handling instruments, and a more intimate knowledge of the problems than he would in larger parties. The drawing periods take up the remaining third of the term and in them each student makes a pencil map of a preliminary line surveyed in Course 260-A and prepares a detailed "paper location" report based on these data. A tracing and profile of the final location as run in the field is then required, also a computation of part of the earthwork. Textbooks: Pickels & Wiley, *Route Surveying* and Crandall, *Earthwork Tables*. One recitation and two field or drawing periods a week. Professor BARNES and Associate Professor THATCHER, Assistant Professors CRANDALL and PERRY.

261. *Railroad Maintenance of Way.* Elective. Seniors and graduates. This course or course 266 is required for seniors in the Transportation Engineering Option in Civil Engineering. First term. Credit three hours. Prerequisite, course 260-B. The subjects treated are track materials (with special reference to the section, method of manufacture, and composition of steel rails, to the economics of tie preservation and the use of metal ties, and to the effect of quality of ballast upon maintenance); machine and other methods of grading for second track; drainage; track laying by both machine and hand methods, ballasting and bringing new track to line and grade; turnouts and switches; derailing switches; side tracks and yard tracks; sorting and terminal yards; track maintenance; track tools, work trains; action of car wheels on curves; widening of gage; double tracking; separation of grades; and improvement in grades and alinement. Textbook: Tratman, *Railway Track and Maintenance.* Lectures and recitations three hours a week. Professor BARNES and Assistant Professor PERRY.

262. *Railroad Operation and Management.* Elective. Seniors and graduates. This course or course 267 is required of seniors in the Transportation Engineering Option in Civil Engineering. Second term. Credit three hours. Prerequisite, course 260-B. Under organization, the following subjects are treated: general principles underlying organization and the effect of each on efficiency; principal departments of railway service with a brief outline of the work of each; departmental and divisional systems of organization, with examples on various roads and discussion of adaptability of each. The duties of officers and the work of the different departments are taken up

in considerable detail. The most important laws affecting railroads are given in discussing the work of the legal department. Freight traffic, freight houses, classification yards, car service rules, accounting, etc., are among the topics considered under operation. Signaling and interlocking and train rules are also considered. Lectures and recitations three hours a week. Professor BARNES and Assistant Professor PERRY.

263. *Route Location.* Required of juniors in the Transportation Engineering Option in Civil Engineering. Elective for seniors and graduates. Second term. Credit three hours. Prerequisites, courses 260-A and 260-B. A detailed study is made of the economic principles and other factors governing the location of new routes for both railroads and highways, and the revision of existing lines to effect the most efficient and satisfactory transportation. Some of the topics treated are estimation of traffic and revenue; costs and rates; steam, electric, and other locomotive and motor operation; gradients, distance, curvature, and rise and fall; line and grade revisions; grade crossing eliminations; location surveys and estimates. Lectures and recitations with problems involving investigations of projects, revisions, and comparisons of alternate routes. Textbook: Williams, *Design of Railway Location.* Three hours a week. Professor BARNES.

264. *Engineering Construction.* Required of all Civil Engineering sophomores. Either term. Credit three hours. A fundamental course designed to acquaint the student with the financial and economic principles underlying human enterprises, both public and private; and with the agencies—money, men, materials, and machines—utilized in carrying out construction projects, and their correlation and control. About one-third of the term is devoted to such topics as the history of engineering and the role of the civil engineer in the progress of civilization, cooperation with other professions, day labor and contract methods of control, types of contracts, elements of cost, including depreciation and overhead, life and economic selection of structures, planning and plant layouts including the plotting and use of the Mass Diagram. The other two-thirds of the term are devoted to the methods and processes of construction with special attention to the equipment available and its adaptability to various kinds of work. Problems and reports on references to periodical literature are required of all students. Lectures and recitations three hours a week. Professor BARNES, Associate Professor THATCHER, and Assistant Professors CRANDALL and PERRY.

265. *Highway Engineering.* This course has been consolidated with N.C.E. 17 (see later).

265-A. *Low Cost Roads.* Elective. Seniors and graduate students. Either term. Credit three hours. Prerequisite, course 265 or its equivalent. Study of economic importance of routes and selection of farm to market roads to be improved; location and design; subgrade soils and stabilization of subgrade soils by use of admixtures, chemicals, and bituminous materials; drainage and drainage structures; bituminous treatments and bituminous mats for stabilized subgrades. Survey of the experimental work in the use of materials and design and construction of low cost roads. Design, construction, and maintenance of road mixes, plant mixes, etc. Professor MALCOLM.

266. *Highway Laboratory.* Elective. Seniors and graduates. This course or course 261 is required of seniors in the Transportation Engineering Option in Civil Engineering. Either term. Credit three hours. Prerequisite, course 265 or may be taken concurrently with course 265. Non-bituminous and bituminous materials are tested. Subgrade soils are sampled and their properties examined; subgrade stabilization admixtures are also tested and studied. Bituminous mixtures are designed, and their properties examined. Professor MALCOLM.

266-A. *Advanced Highway Laboratory.* Elective. Seniors and graduates. Either term. Credit three hours. Prerequisites, courses 265 and 266. Non-bituminous and bituminous materials are tested and their characteristics studied. Soils are sampled and examined, and investigations made of the behavior of mixtures of soils with bituminous and non-bituminous materials. Special investigations and tests are made to determine the properties of various combinations of materials and the effects of modifications in design. Two laboratory periods a week. Professor CONWELL. Not given during the emergency.

267. *Advanced Highway Engineering.* Elective. Seniors and graduates. This course or course 262 is required of seniors in the Transportation Engineering Option in Civil Engineering. Second term. Credit three hours. The topics for assignment and discussion include the economics of highway engineering, highway finance, legislation, regulation, traffic, design, construction, and maintenance of highways, the latest research programs and reports, labor and plant organization for various kinds of highway contracts with especial emphasis on the economics of contracting, etc. This course is conducted as a seminar. Meetings are held once each week at hours to be arranged. Professor CONWELL. Not given during the emergency.

268. *Modern Highway Planning and Design.* Elective. Seniors and graduate students. Second term. Credit three hours. Prerequisite, course 265 or its equivalent. Study of geographical, political, and economic divisions of communities with particular reference to highway transportation requirements; analysis of regional plans chiefly concerning the classification of roads and the selection of routes to be abandoned or improved, based upon their economic justification. Design of regional systems of highways, freeways, and parkways, including the consideration of the economic, safety, and aesthetic aspects. Traffic studies, legislation, financing, and zoning. Design of intersections and grade separations. Problems and reports required. Professors CLARKE and CONWELL. Not given during the emergency.

269. *Transportation.* Required of seniors in the Transportation Engineering Option and the B.S. in A.E. Course in Civil Engineering and may be elected by other qualified seniors and graduates. Second term. Credit three hours. A course covering travel and transport agencies with special reference to their facilities, ownership, financing, regulation, and coordination. A brief review of the development of transportation throughout the world is used as a background for an intensive study of the present situation in the various countries and comparison of the policies and practices in use. Particular attention is given to the various proposals designed to promote more efficient use of the various transportation agencies in the United States by better coordination, pooling of facilties, etc., and economic

studies are made of some of the new projects which are under discussion. Professor BARNES.

(For *Railroad and Highway Engineering Design and Research*, see Courses 291e, 291g, 297e, 297g.)

### STRUCTURAL ENGINEERING

270. *Stress Analysis and Structural Design.* Required of all juniors in Civil Engineering. Either term. Credit four hours. Prerequisites, course 220 and 221.

*Stress Analysis.* Graphic analysis of simple and cantilever beams, roof trusses, and framed bents. Determination of position of moving concentrated loads for maximum shears and moments in beams and deck girders; also for through girders and maximum floor beam reactions for same. Stresses due to dead load, live load, impact, and wind load in the principal types of simple trusses employed in modern construction. Stiff web systems and counter bracing. Three-hinged roof and bridge arches. Practical problems in actual stress computation throughout the course. Textbook: Urquhart and O'Rourke's *Stresses in Simple Structures.* Three recitations a week.

*Structural Design.* Graphic analysis of stresses in a timber truss. Design of truss members and joint details. Computations, systematically arranged in the form of reports, and working drawings. Textbook: Jacoby and Davis's *Timber Design and Construction.* Computation and drawing, two and one-half hours a week. Professor O'ROURKE, Associate Professor BURROWS, and Assistant Professor H. M. GIFFT.

270-A. Required of Army graduate students who are candidates for the M.S. in Engineering degree. Credit three hours. A course based on the content of course 270. Two recitations and one design period a week. Professor MALCOLM.

271. *Structural Design.* Required of all juniors or seniors in Civil Engineering. Either term. Credit three hours. Prerequisite, course 270 or 270-A. An elementary course in steel design. Principles of both riveted and welded connections. Complete designs and detail drawings of the steel skeleton of a small building, including trusses, and of a through plate girder bridge. Textbook: Urquhart and O'Rourke's *Design of Steel Structures.* Three computation or drawing periods a week. Professor O'ROURKE, Associate Professor BURROWS, and Assistant Professor H. M. GIFFT.

272. *Advanced Structural Analysis.* Elective for seniors and graduates and required of seniors in the Structural Engineering Option in Civil Engineering and of all graduate students majoring or minoring in structural engineering. Either term. Credit three hours. Prerequisite, course 270. Stress analysis of continuous beams, framed bents, and rigid frames. Horizontal as well as vertical loading considered. Redundant structures including the braced two-hinged arch. Displacement diagrams for trusses and arches and analytical computation of deflections of such structures. Three recitations a week. Professor O'ROURKE.

273. *Steel Buildings.* Elective. Seniors and graduates. Any term. Credit three hours. Prerequisites, courses 220, 221, and 271. This course comprises the design of the steel framework for buildings of the prevailing type used in power house or shop construction. Dead, snow, and wind stress diagrams are drawn for the roof trusses. Provision is made for an electric crane moving the full length of the building and the stresses in the frame work due to the movement of the crane are determined. The effect of the wind and the eccentric load due to the crane girder are considered in the design of the columns. Textbook: Ketchum's *Steel Mill Buildings.* Reports and drawings. Three two-hour periods a week. Associate Professor BURROWS.

274. *Bridge Design.* Elective. Seniors and graduates. This course or course 284 is required for seniors in the Structural Engineering Option in Civil Engineering. Second term. Credit three hours. Prerequisite, course 271. Computations and drawings for the complete design of a railroad bridge of six or seven panels or a heavy highway bridge. The computations to determine the stresses and sections of all members, pins, pinplates, splices, deflection, camber, and other details as well as of connecting rivets are to be written up in the form of systematically arranged reports. The drawings consist of general detail plans showing the location of all rivets as well as the composition and relation of all members and connections. The final report is to give a full list of shapes and plates, and a classified analysis of weight for the span. Textbook: Johnson, Bryan & Turneaure, *Modern Framed Structures, Vol. III.* Computation and drawing, three two-hour periods a week. Associate Professor BURROWS. Not given during the emergency.

275. *Investigation of Existing Bridges.* Elective. Seniors and graduates. Second term. Credit three hours. Prerequisite, course 271. Inspection of existing structures for the determination of sizes and conditions of plates and shapes. After full data have been obtained in the field, computations will be made to determine either the unit stresses under a specified load, or the safe load or rating according to standard specifications. Hours as assigned. Associate Professor BURROWS. Not given during the emergency.

279. *Elements of Structural Engineering.* Elective. Seniors in Electrical Engineering. Any term. Credit two hours. Analysis and design of beams of steel, timber and concrete, columns, footings, and retaining walls. Textbook: Urquhart & O'Rourke's *Elementary Structural Engineering.* One lecture and one computing period a week. Professor MALCOLM.

280. *Concrete Construction.* Required of all Civil Engineering juniors. Either term. Credit three hours. Prerequisites, courses 220 and 221. (Preferably taken concurrently with or preceded by course 225.) Properties of plain concrete, elementary theory of reinforced concrete as applied to rectangular beams, slabs, T-beams, beams reinforced for compression, columns, and footings. Shear, diagonal tension, and direct stress combined with flexure. Computations in the forms of reports on the design of a typical beam and girder floor panel and of a retaining wall. Detail sketches of sections and reinforcement required. Textbook: Urquhart and O'Rourke's *Design of Concrete Structures.* Six hours a week. Professor O'ROURKE and Assistant Professors GIFFT and WINTER.

280A. *Concrete Construction.* For architects. First term. Prerequisites, Arch. 210 and 211, or C.E. 220 and 221. (Students who have taken C.E. 220 and 221 may substitute 280 for 280A.) Credit three hours. Properties of plain concrete, elementary theory of reinforced concrete as applied to beams and slabs, columns, footings, and retaining walls. Textbook: Urquhart and O'Rourke's *Design of Concrete Structures.* Three two-hour periods a week. Professor O'ROURKE and Assistant Professor GIFFT. Not given during the emergency.

281. *Foundations.* Required of all Civil Engineering juniors or seniors except in the B.S. in A.E. Course. Either term. Credit three hours. Prerequisites, courses 220 and 221. Piles and pile driving, including timber, concrete, tubular and sheet piles; cofferdams; box and open caissons, pneumatic caissons for bridges and buildings, caisson sinking, and physiological effects of compressed air; pier foundations in open wells; freezing process; hydraulic caissons; ordinary bridge piers; cylinders and pivot-piers; bridge abutments; spread footings for building foundations; underpinning buildings; subterranean explorations; unit loads. Textbook: Jacoby and Davis's *Foundations of Bridges and Buildings.* Recitations, collateral reading in engineering periodicals, and illustrated reports. Three hours a week. Professor O'ROURKE.

282. *Reinforced Concrete Building Design.* Elective. Seniors and graduates. Either term. Credit three hours. Prerequisite, course 280. Design of a reinforced concrete flat-slab building and investigation of various other types of floor systems for commercial buildings. Complete detail design for one building, including stairway, elevator shafts, penthouses, etc. Working drawings and steel schedules. Textbook: Urquhart and O'Rourke's *Design of Concrete Structures.* Seven and one-half hours a week. Professor O'ROURKE. Not given during the emergency.

283. *Fixed Arches.* Elective for seniors and graduates and required for seniors in the Structural Engineering Option in Civil Engineering. First term. Credit three hours. Prerequisites, courses 270, 271, and 280. Theory of the curved beam; the closed ring; the fixed arch. Influence lines for arches of various forms. Selection of curvature of axis for various loadings. Effect of temperature and rib-shortening. Effect of plastic flow on stresses in a reinforced concrete arch. Design of a reinforced arch and its abutments. Lectures, recitations, and computations. Six hours a week. Professor O'ROURKE.

284. *Highway Bridges.* Elective. Seniors and graduates. This course or course 274 is required for seniors in the Structural Engineering Option in Civil Engineering. Second term. Credit three hours. Prerequisite, course 280. Design of short span bridges and their abutments. Comparison of the economy of steel and reinforced concrete superstructures for bridges of this type. Reports and drawings. Professor O'ROURKE. Not given during the emergency.

285. *Reinforced Concrete Design.* Elective for seniors and graduates and required for seniors in the Structural Engineering Option in Civil Engineering. Either term. Credit three hours. Prerequisite, course 280. Design of footings: single and multiple columns of reinforced concrete, I-beam grillages. Design of bins and tanks, subsurface and supported on towers.

Design of a highway bridge. Reports and sketches. Three two-hour periods a week. Professor O'ROURKE.

286. *Elastic Foundations and Thin Structural Shells.* Elective. Primarily for graduate students. First term. Credit three hours. Study of the properties of elastic foundations and the application of the elastic foundation theory to the analysis of large diameter, low head tanks, hemispherical domes, hemispherical leaders on large pipes, and thin shell pipes under flexure. Three hours a week. Not given during the emergency.

287. *Soil Mechanics.* Required of juniors in the Regular Four-Year Course and the Sanitary, Structural, Hydraulic, and Transportation Engineering Options in Civil Engineering. Either term. Credit three hours. A comprehensive study of the properties of soil, presenting a conception of its behavior as an engineering material. Theory of soil classification, soil structure, pressure distribution, compressibility, cohesion, elasticity, plasticity, and permeability. Laboratory tests for identification of soils; mechanical analysis, determination of water content, specific gravity, density, permeability, etc. Tests for physical properties of soils. Two lectures and one laboratory period a week. Professor O'ROURKE and Assistant Professor JENKINS.

288. *Applied Soil Mechanics.* Elective for seniors and graduate students. Second term. Credit three hours. Prerequisite, course 287. Advanced application of soil mechanics, based on the principles and physical studies of course 287. The plastic flow theory; the consolidation theory; stability of earth slopes; flow of water through earth structures; theories of earth pressure on retaining walls, caissons, and tunnels. Review of modern soil mechanics research. Not given during the emergency.

(For *Structural Engineering Design and Research*, see Courses 291a, 291f, and 297f.)

ADMINISTRATIVE ENGINEERING

290. *Engineering Law.* Required of all Civil Engineering seniors. Juniors admitted only by special permission. Also open to seniors in Architecture, Mechanical, Chemical, and Electrical Engineering, and other seniors submitting acceptable qualifications. Either term. Credit three hours. Essentials of contracts and contract principles; agency, tort, and independent contractor; use and conveyance of lands and waters, including irrigation law, real estate documents, boundary lines, eminent domain and title searches; corporations, partnerships and other contracts of association; sales and transportation contracts; negotiable instruments; bankruptcy, mechanics liens, patents, trademarks, copyrights, courts, wills, and laws of insurance. The course culminates with the preparation of a set of contract documents for an assigned construction job, including advertisement, bond, form of proposal, information to bidders, agreement form, specifications, and general conditions with clauses covering payments, time limit, arbitration, extras, liquidated damages, and abandonment of contract. Tucker's *Contracts in Engineering* is used as a text, supplemented liberally from other sources. Lectures and recitations three hours a week. Professor BARNES, Associate Professor THATCHER, and Assistant Professors CRANDALL and PERRY.

290-A. *Advanced Engineering Law.* Required of seniors in B.S. in A.E. Course in Civil Engineering and open to others who have completed course 290. Any term. Credit three hours. Some of the topics treated in course 290 are here enlarged upon and extended, particularly laws relating to the various phases of construction contracts, employer-employee relationship, workman's compensation, mechanics liens, patents, copyrights, trademarks, and insurance. Among other subjects covered are suretyship, conditional sales, bailments, trusteeship, and taxation. Actual cases are used for illustrating the above and reference is also made to recent court decisions regarding engineering matters. Lectures and recitations three hours a week. Textbook: Simpson & Dillavou's *Law for Engineers and Architects.* Professor BARNES and Associate Professor THATCHER.

293. *Engineering Management.* Required of juniors in the Regular Four-Year Course and the Transportation and Geodetic Engineering Options in Civil Engineering. Also open to qualified juniors and seniors in other courses. Either term. Credit three hours. This course is devoted mainly to the management of construction work but also treats briefly of such larger problems as economics of plant location and economic selection of plant, or structure, to fulfill a given purpose. Management is treated under its two main heads—planning and operation. Under planning are such subjects as the selection of methods of procedure which will result in maximum economy, the planning of a thoroughly coordinated organization of men and machines to carry out these methods, and the scheduling and estimating of the work in accordance with the adopted plans. Under operation are selecting, training, and maintaining labor forces including pay systems, accident prevention, welfare work, etc., purchasing, operation, and maintenance of equipment, and keeping the records essential to the management for comparing results with schedules, i.e., cost keeping. Bookkeeping is recognized also as an essential tool of management and the fundamentals of double entry bookkeeping are given, together with the use of control accounts, financial statements, and budgets. Blanks and forms for cost keeping for actual or assumed jobs are required and each student also works out problems in bookkeeping. Lectures and recitations three hours a week. Professor BARNES and Assistant Professor CRANDALL.

293-A. *Engineering Management.* Required of juniors in the Administrative Engineering Option and the B.S. in A.E. Course in Civil Engineering. Second term. Credit three hours. Prerequisite, an elementary course in accounting. Covers the same ground as course 293 except that bookkeeping is omitted and more attention is given to management proper, especially to personnel and labor relations. Cost accounting on engineering construction work is included. Three hours a week. Professor BARNES. Not given during the emergency.

295. *Valuation Engineering.* Elective for seniors and graduates and required for seniors in the B.S. in A.E. Course in Civil Engineering. Second term. Credit three hours. Prerequisite, course 264 and 290 or taken concurrently with 290. Theory and practice of valuation or appraisal for purposes of utility rate making, purchase or sale, eminent domain or condemnation cases, mergers or joint ownership, taxation and assessment, issuance of securities, bank loans, insurance, uniform system of accounting, and

improved management. Topics considered include scientific systems of real estate assessment, federal railroad valuation, rate disputes, court rulings, compution of actual rates for gas, telephone, electrical supply and street railways, valuation of land, mines, water power, factories, railroads, toll bridges, buildings, and all kinds of property both tangible and intangible. Detailed examples of forms and methods with outline of typical valuation reports. Lectures, recitations, and reports. Textbook: Marston and Agg's *Valuation Engineering*.

### REGIONAL AND CITY PLANNING

(By cooperation of the College of Architecture)

710. *Principles of Regional and City Planning.* Elective. Registration limited to 50. Open to graduates and upperclassmen in all colleges of the University. First term. Credit three hours. The history of the planning of communities, including provisions for housing from ancient times to the present. A review of the basic influences in the development of cities. A general view of the theory and accepted practice of city and regional planning including a study of the social, economic, and legal phases. Occasional lectures may be given by members of other faculties and by outside lecturers selected because of their special experience and skill in certain phases of planning. Lectures, assigned reading, and examinations. M W F 12. *White 201.* Professor CLARKE and Assistant Professor MACKESEY.

711. *City Planning Practice.* Elective. Second term. Credit three hours. Prerequisite, course 710. The procedures and techniques of gathering and analyzing data for municipal planning studies. The selection and integration of data for use in planning. Practical application of the theories of city planning. Office practice. Lectures, assigned reading, reports. M W F 12. *White 201.* Professor CLARKE and Assistant Professor MACKESEY of the College of Architecture.

712. *Regional Planning Practice.* Elective. Open to graduates and upperclassmen in all colleges of the University. Second term. Credit three hours. Prerequisite Course 710. A study of the principles involved in county, regional, state, and national planning. Includes discussion of following factors involved: land use, water resources, recreation, transportation, public services, and public works. Occasional lectures will be given by members of other faculties and outside lecturers. Lectures, assigned reading, reports, and examinations. Hours to be arranged. Professor CLARKE and Assistant Professor MACKESEY of the College of Architecture.

713. *Housing.* Elective. Registration limited. First term. Credit two hours. Prerequisite course 710. An introduction to the theory and standards of housing practice through analysis and comparison of various existing examples, considering the social, economic, and technical sides of the work. Students in the College of Architecture will take one or more design programs having some phase of housing as subject. These programs will be substituted for a regular problem in courses 113 or 151, and values, as earned, will be awarded in those courses. Lectures, assigned reading, and reports. Hours to be arranged. *White 201.* Professor CLARKE, and Assistant Professor MACKESEY of the College of Architecture.

714. *Seminar in Regional and City Planning.* Elective. Throughout the year. Credit one hour each term. This course should accompany or follow course 710. Registration limited. Open to students in all colleges of the University, by permission. Investigation of assigned topics on particular aspects of the subject with emphasis on either urban or regional planning. Hours to be arranged. *White, Architectural Seminar Room.* Professor CLARKE and Assistant Professor MACKESEY of the College of Architecture.

715. *Seminar in Park Planning.* Elective. Registration limited. Open to upperclassmen and graduates in the Colleges of Architecture and Engineering and others by special permission. First term. Credit two hours. Specific problems relating to the design of city, state, and national parks with a study of examples. T 8–10. *White B-15.* Professor CLARKE. (Not given in 1944–45.)

716. *Seminar in Parkway, Freeway, and Highway Planning.* Elective. Registration limited. Open to upperclassmen and graduates in the Colleges of Architecture and Engineering. Second term. Credit two hours. Specific problems relating to the design of the modern parkway, freeway, and highway with a study of examples. T 8–10. *White B-15.* Professor CLARKE.

717. *Zoning Principles and Practice.* Open to graduates and upperclassmen in all colleges of the University. Second term. Credit two hours. Prerequisite, course 710. Technical and legal aspects of drafting and administering zoning regulations. Hours to be arranged. Assistant Professor MACKESEY.

### GENERAL COURSES

291. *Engineering Design.* Elective. Seniors. Credit three or more hours. The student may make complete designs in one of the following sub-divisions, subject to approval. Hours to be arranged.

(a) *General Civil Engineering.* Either term. Problems in practical design may be taken in any department, the work to be supervised by the department concerned in cooperation with the Department of Structural Engineering in regard to structural features.

(c) *Hydraulic Engineering.* Any term. Prerequisite course 240. For best results Hydraulic Engineering Design should be preceded by Course 230, but the two may be taken concurrently. The purpose of the course is to go more into detail in selected phases of hydraulic engineering and is not to duplicate in large part work regularly given in the scheduled courses in hydraulic and structural engineering. Professor DOTY.

(d) *Sanitary Engineering.* Either term. Credit three hours. This course should be preceded by Courses 252 and 253-A or equivalent courses. The purpose of the course is to teach methods of determining the capacity, basis of design, computations, sketches, and general plans and profiles involved in the design of sewerage, trade waste, and water treatment works. Problems may be elected such as the design of a separate or combined sewerage system, an intercepting sewer, a municipal or an institutional sewage treatment plant, a plant for the treatment or disposal of an industrial waste, or a plant for the treatment of an industrial, institutional, or municipal water supply. Professor WALKER.

(e) *Railroad Engineering.* Either term. The problems are those encountered in the location and construction of railroads, and include the following subjects: Economic location of railroads; culverts; bridges; retaining walls; tunnel and subway design; small depot buildings; freight houses; water supply and coaling plants; icing stations; turntables and engine-houses; gravel washing plants; track layouts with details of signals and interlocking; yard and terminal design, etc. Bills of material and estimates of cost are usually required. The field is so broad that the interest of the student is given consideration in assigning problems. Professor BARNES and Assistant Professor PERRY.

(f) *Structural Engineering.* Either term. Prerequisite, courses 270, 271, and 280. The student may select a problem such as the following: (a) an arch bridge of steel, (b) a cantilever bridge, (c) a rigid frame bridge, (d) a special problem in steel or concrete building design, (e) the design of any other structure of particular interest to the student provided he has had the proper preparation for such design. The work is submitted in the form of reports. Drawings of typical details must accompany reports. Professor O'ROURKE and Associate Professor BURROWS.

(g) *Highway Engineering.* Either term. The problems are those encountered in the selection, location, design, and construction of highways. They include the following: Economic selection of routes, economic location, design of highways, highway intersections, culverts, highway bridges, retaining walls, and other highway structures. Bills of materials and estimates of cost are usually required, also plant layouts and methods of executing work. Professor CONWELL.

297. *Engineering Research.* Elective. Seniors and graduates. Credit three or more hours. Research may be taken in one of the following subdivisions or two or more departments may cooperate in the assignment of special problems. Hours to be arranged.

(a) *Geodetic Astronomy.* Any term. Prerequisites, courses 186 and 216. Investigations of instrumental errors; variation of latitude and azimuth; any and all questions relating to work of the highest precision connected with astronomical problems and geodetic operations. The field is so broad that the interest of the student is given consideration as to the actual research undertaken. Professor UNDERWOOD.

(b) *Engineering Materials.* Either term. Credit one hour for forty hours of actual work. A project may be started during the junior year for completion in the senior year. Prerequisites, courses 225 and 226 or their equivalents. Special investigations of an advanced nature of the properties of structural units and the materials of construction. The aim of the course is to secure results by proper investigational methods which are of the caliber and scope deemed essential for publication. Professor SCOFIELD.

(c) *Hydraulics.* Either term. Prerequisite, course 240 or its equivalent. The subject and scope of the investigations in experimental or theoretical hydraulics should be selected by conference at the beginning of the term if not previously arranged. It is often desirable and is permissible for two students to work together on the same investigation. Written reports are required but the text need not be typewritten in thesis style. These reports

are kept by the department. In most cases it is necessary to arrange a definite schedule for work in the laboratory to avoid conflicts. Professor SCHODER.

(d) *Sanitary Engineering.* Either term. Prerequisites for work in this field will depend upon the particular problem to be pursued, but in general will include work in water analysis, bacteriology, and courses in Hydraulics and Sanitary Engineering dealing with the field in which the work is to be undertaken. Hours, credit for work, prerequisites and other questions relating to contemplated research in this field will be arranged by conference. Professor WALKER.

(e) *Railroad Engineering.* Either term. Special problems in the economics of location, construction, maintenance and operation of railroads, comparison of transportation agencies, traffic studies, and economics of various systems of transport. Professor BARNES.

(f) *Structural Engineering.* Any term. Students wishing to pursue one particular branch of bridge engineering further than can be done in any of the regular courses may elect work in this field. The prerequisite courses depend upon the nature of the work desired. The work may be in the nature of an investigation of existing types of construction or theoretical work with a view to simplifying present methods of design or proposing new methods. Professor O'ROURKE and Associate Professor BURROWS.

(g) *Highway Engineering.* Either term. Prerequisites, courses 265 and 266. Studies of traffic and traffic regulation and legislation may be made. The field of economics of highway engineering offers a wide variety of problems. Laboratory investigations of subgrade soil, subgrade stabilization, and the effects of modifications in design of bituminous and non-bituminous mixtures provide a wide range of topics for research. Professor CONWELL.

(h) *Management Engineering.* Either term. Special problems relating to the economic, legal, and financial aspects of engineering construction projects, management of public works and appraisals. Professor BARNES.

(i) *Geodetic Engineering.* Either term. Prerequisites will depend upon the line of work to be pursued. Special problems in least squares, reduction of triangulation, and photographic surveying as may be arranged. Professor UNDERWOOD.

298. *Thesis.* Elective. Seniors. Either term. Credit three or more hours. The thesis gives the student, desiring to work out a special problem or make an engineering investigation, and to record the result of his work, the opportunity of so doing. Registration for thesis must be approved by the professor in charge at the beginning of the semester during which the work is to be done.

### SPECIAL AND GRADUATE COURSES

All the elective courses are suitable for graduate and advanced students, and may be taken by them in the regular classes. Other special courses will be arranged to suit the requirements of graduate students. These special courses are intended to be pursued under the immediate direction of the

professor in charge, the student usually being free from the restriction of the classroom, and working either independently or in conjunction with others taking the same course.

## MECHANICAL ENGINEERING

### ADMINISTRATIVE ENGINEERING (A)

3A21. *Economic Organization.* Each term. Credit three hours. Three lectures a week with collateral reading. A study of the form and functioning of our economic system with special emphasis on those features which are of particular interest to engineers. Professor GARRETT and Mr. FITZGERALD.

3A22. *Economic Organization Problems.* For E.E. students. Alternate terms. Credit three hours. Prerequisite 3A21. Three recitations a week. A more intensive study of certain economic problems which are touched only briefly in course 3A21. Professor GARRETT.

3A31. *Principles of Industrial Accounting and Cost Finding.* Each term. Credit three hours. Two recitations and one computing period a week. A basic course in modern industrial accounting and in cost finding. Associate Professor HANSELMAN and Mr. FITZGERALD.

3A33. *Technical Reports.* Each term. Two recitations a week. The writing of technical reports, business letters, articles and editorials, with emphasis on terse and vigorous diction and effective arrangement of ideas. Mr. SAMPSON.

3A34. *Corporation Finance.* Each term. Credit three hours. Prerequisite courses 3A21 and 3A31. A study of the financial problems of the business corporation from the points of view of the management, the investor, and the public. Professor O'LEARY.

3A35a. *Industrial Organization and Management.* Each term. Credit three hours. Lectures, discussion, problems, and collateral reading. An elementary survey of problems of management in industrial organization, with emphasis on factory management. Mr. SAMPSON.

3A41. *Elementary Industrial Statistics.* Alternate terms. Credit three hours. Two recitations and one three-hour computing period a week. The elementary technique of statistical analysis as applied to engineering and industrial problems. Professor GARRETT, Associate Professor LOBERG, and Mr. FITZGERALD.

3A42a. *Personnel Management in Industry.* Each term. Credit three hours. Three recitations a week. A study of human nature as affecting personnel problems in industry. Case demonstrations are used to illustrate the more important problems. Mr. SAMPSON.

3A43. *Engineering Business Law.* Alternating with 3A46. Credit three hours. Three lecture-discussion periods a week. A study of legal principles relating to business transactions, with emphasis on the law of contracts. Through the use of case material, the student is led to apply general principles to specific situations. Associate Professor HANSELMAN.

3A44. *Industrial Marketing.* Credit three hours. Two recitations and one lecture a week. A study of the field of industrial marketing using the case method of instruction. The scope of the course includes product planning, policy, and research; sales and market analysis; distribution channels; pricing and terms of sales; sales promotion; management and organization of sales force; sales control. Associate Professor LOBERG. (Temporarily discontinued.)

3A45. *Industrial Marketing.* Elective. Second term. Credit two hours. One recitation and one laboratory period a week. Prerequisite course 3A44. The application of the principles of marketing to specific problems. Each student will develop a complete market study and analysis for given industrial products. Associate Professor LOBERG. (Temporarily discontinued.)

3A46. *Engineering Business Law.* Alternating with 3A43. Credit two hours. Two lecture-discussion periods a week. A study of business law with special reference to sales and to corporations. By the use of case material, the student is led to apply general principles to particular situations. Associate Professor HANSELMAN.

3A47. *Principles of Cost Control.* Alternate terms. Credit three hours. Prerequisite course 3A31 or its equivalent. This course covers in detail, through work in the laboratory, manufacturing cost systems for job orders and for continuous processes. Budgets and statements are discussed. Associate Professor HANSELMAN and Mr. WHITESEL.

3A49. *Industrial Relations.* Alternate terms. Credit two hours. Prerequisites 3A21 and 3A35a. Two lecture-discussion periods a week. A study dealing principally with the relations between management and labor under recently enacted labor legislation. Professor GARRETT.

3A51. *Business and Industrial Research.* Elective. Any term. Credit one hour for forty hours of actual work. Open to a very limited number of seniors and graduate students who have shown by training and aptitude their ability to carry on original investigations in business and industrial subjects. Professors BANGS and GARRETT, Associate Professors HANSELMAN and LOBERG. (Temporarily discontinued.)

3A52. *Industrial Salesmanship.* Elective. Credit two hours. One recitation and one laboratory period a week. A study of the basic principles of selling and the application of these principles to case problems. Associate Professor LOBERG. (Temporarily discontinued.)

3A53. *Chemical Engineering Economics.* Alternate terms. Credit three hours. The course includes a basis of accounting theory and discussion of cost finding as applied to chemical plants, of the making and analysis of financial statements, and of certain problems peculiar to the chemical industry. Associate Professor HANSELMAN and Mr. WHITESEL.

3A54. *Standard Costs and Management Control.* Alternate terms. Credit three hours. One lecture and two 2½-hour computing periods a week. A detailed study of the use of standard costs and general control of production and sales through the records of costs. Associate Professor HANSELMAN and Mr. WHITESEL.

AUTOMOTIVE AND AERONAUTICAL ENGINEERING (B)

3B35a. *Aerodynamics.* Each term. Credit three hours. Prerequisite courses 3M21 and 3M22a and b. Three recitations a week. Properties of air, airfoil characteristics, drag calculations, engine-propeller characteristics and their relation to airplane performance. Stability calculations, performance estimates, and flight testing. Mr. KOCH.

3B41. *Automotive Lectures.* Seniors and graduates. Alternates with 3B42. Credit two hours. Two lectures a week. Prerequisite courses 3P35, 3P36, 3D37, and 3D38. The automobile, and the power required for its operation, but not including the power plant (for which see course 3B42). Analysis is made of the relations of the car to the road; functions of steering, driving, braking; mechanical efficiency of chassis; springing for comfort of riding; wind resistance; layout of parts for balanced design. Assistant Professor L. L. OTTO.

3B42. *Automotive Lectures.* Seniors and graduates. Alternates with 3B41. Credit two hours. Two lectures a week. Prerequisite courses 3P81, 3D37 and 3D38. Analysis of automotive power plant design and operation; nature of the actual working fluid; preparation for and control of combustion in spark- and compression-ignition engines; volumetric, thermal, and mechanical efficiencies of engines; lubrication, fuels, etc. Assistant Professor L. L. OTTO.

3B43. *Automotive Computations.* Credit two hours; two computing periods a week. Must be accompanied by course 3B41, which it parallels, but with more detailed studies to acquaint students with methods of attack on problems in operation or design. Assistant Professor L. L. OTTO. (Temporarily discontinued.)

3B44. *Automotive Power Computations.* Credit two hours. Two computing periods a week. Must be accompanied by 3B42, which it parallels, but with more detailed studies in operation and design. Assistant Professor L. L. OTTO. (Temporarily discontinued.)

3B46. *Airplane Design.* Seniors. Alternate terms. Credit two hours. Prerequisite 3B35a. Two recitations a week. Layout procedure, weight and balance estimates, load factors, materials, and costs. Principles of stress analysis and airplane computations. Mr. KOCH. (Temporarily discontinued.)

3B47, 3B48. *Airplane Computations.* Two successive terms. Credit two hours a term. Prerequisite course 3B35; and must be accompanied or preceded by 3B46. Two computing periods a week. The student makes calculations and drawings similar to those required by the Department of Commerce for approval of the design of an airplane. Mr. KOCH. (Temporarily discontinued.)

3B50. *Advanced Automotive Engineering.* Elective for qualified seniors and graduates. Each term. Credit two to five hours as arranged. Selected advanced topics and special problems. Assistant Professor L. L. OTTO and Mr. KOCH.

### DRAWING AND DESCRIPTIVE GEOMETRY (C)

3C11. *Drawing and Descriptive Geometry.* Each term. Credit three hours. One recitation and two drawing periods a week. Coordinated instruction in subjects prerequisite to a study of the engineering applications of drawing. The drafting arts. Geometric analysis and composition of structures including considerations of the elements of structure and their properties, interspace relations of structural elements, determinants of elements and structural organization along paths of physical and functional ties. Graphic computation and description of the geometric qualities and quantities of structure. Professor TOWNSEND, Associate Professor CLEARY, and instructors. *East Sibley.*

3C12. *Mechanical Drafting.* Each term. Credit three hours. One recitation and two drawing periods a week. Prerequisite course 3S11 and must be taken with or preceded by courses 3C11 and 3S14 or 3S15. Studies of mechanical anatomy are coordinated in this course with studies in the three functional divisions of mechanical drafting, namely: (1) the creative division or layout drafting; (2) the expressive division or detail drafting; (3) the interpretation division or blueprint reading. Freehand sketching, pictorial drawing, tracing, etc., are studied as applied in this work. Professor TOWNSEND, Associate Professor CLEARY, Assistant Professor MORDOFF, and instructors. *East Sibley.*

3C14, 3C15. *Drawing.* For students in Chemical Engineering. Two terms. Credit two hours a term. One recitation and one drawing period a week. A brief course in the basic subjects of drawing and the techniques of applying these subjects to the determination of structure by layouts and the specification of structure on working drawings. Professor TOWNSEND, Associate Professor CLEARY, and instructors.

### MACHINE DESIGN (D)

3D25. *Kinematics, Recitations.* Each term. Credit three hours. Prerequisite courses, Drawing and Descriptive Geometry 3C11, Mechanical Drafting 3C12, and Mathematics 60a and 60b. Three recitations a week throughout the term on the theory of motion; the transmission of motion; the instant-center method of determining linear and angular velocities; cams; rolling curves and friction gearing; gears and gear cutting; linkwork and miscellaneous mechanisms; belt, rope, and chain drives; and trains of mechanism. Professor ROGERS, Assistant Professor JOHNSON, and Messrs. MORRIS, GATCOMBE, HINKLE, CARRIER, and NOTHMANN.

3D26. *Kinematics, Drawing.* Each term. Credit two hours. Must be taken with course 3D25. Two drawing periods a week throughout the term devoted to drawing-board applications of the theory and principles of course 3D25. Same staff as for 3D25.

3D37. *Machine Design, Recitations.* Fifth-term students, Each term. Credit three hours. Prerequisite courses 3D25, 3D26, 3T22, 3S23 and 3M22a. Three recitations a week throughout the term on the theoretical and practical applications of kinematics, materials, mechanics, and technology to the design of machines and machine elements with due regard to such considerations as suitability of materials, safety, lubrication, construction, etc. Associate Professor BLACK and Messrs. HINKLE and NOTHMANN.

3D38. *Machine Design.* Sixth-term students. Each term. Credit two hours. Prerequisite course 3D37. Two design periods a week throughout the term. The student for the first time undertakes the design of machine parts and assemblies and makes all the necessary calculations and drawings. Orderly, systematic calculations are insisted upon and such layout and detail drawings are made as are found necessary to complete each problem. Professor ALBERT, Associate Professor BLACK, Assistant Professor JOHNSON, and Mr. NOTHMANN.

3D51. *Tool Engineering.* Elective. Each term. Credit two hours. Prerequisite 3M22a, 3T21, 3T22, 3S23 and 3S24. One discussion and one computing period a week. The course deals with the theory and principles of operation underlying the design of punches, dies, jigs, and fixtures and with the application of such tools to the production of parts of appliances and machines in small and in large quantities. Assistant Professor JOHNSON.

3D52. *Advanced Kinematics and Kinetics.* Elective for qualified undergraduate and graduate students. Alternate terms. Credit three hours. Prerequisite courses 3D25 and 3D26. About twenty-four lecture and discussion periods and about twenty-one three-hour drawing periods during the term, for which two one-hour and two three-hour periods a week must be provided in the student's schedule. Graphical and semigraphical treatment of linear and angular velocities and accelerations and of the resulting forces, stresses, and strains due to the form and mass of the moving parts of mechanisms and machines. Vibration and critical speeds and the theoretical basis and use of balancing machines for securing static and running balance of machine parts will be treated as far as time permits. Professor ROGERS. (Temporarily discontinued).

3D53. *Materials Handling.* Elective for qualified undergraduates and graduates. Alternate terms. Credit two hours. Prerequisite courses 3D25 and 3D26. Two lectures a week throughout the term. Treatment and analysis of the known methods of handling different kinds of materials and of the principles and considerations involved in a proper choice of the method of handling any given kind of material. (Temporarily discontinued).

3D54. *Dynamics and Vibrations of Machinery.* Elective for qualified undergraduates and graduates. Alternate terms. Credit three hours. Prerequisite course 3D37. Two lecture and discussion periods and one computing period a week throughout the term. Graphical and analytical treatment of velocities, accelerations, static forces, inertia forces, and combined forces. Balancing of engines. Transverse and torsional vibrations, critical speeds, and balancing machines. Determination of forces in automotive engines. Associate Professor BLACK.

3D55. *Advanced Machine Design.* Elective for undergraduates and graduates. Credit three hours. Prerequisite course 3D37. Three lecture and discussion periods a week throughout the term. Advanced problems in stress analysis of machine and structural members including consideration of fatigue, creep, stress concentration, stability, etc. Vibration and lubrication. Special problems. Associate Professor BLACK.

3D56. *Design of Pressure Vessels.* Elective for graduates and qualified undergraduates. Alternate terms. Credit two hours. One discussion and

one computing period a week. The course deals with the design of thin and thick pressure vessels under internal or external pressure, or both, and with the stresses in such vessels and in flat plates, flanges, heads, openings, and connections. Mr. CARRIER.

3D57. *Welding in Machine Design.* Elective for seventh and eighth-term students. Alternate terms. Credit two hours. One discussion and one computing period a week. The course deals with flame cutting and methods of welding, with shrinkage, warpage, and stress relieving, with inspection and testing, with the design of welded joints, and with the application of fusion welding in the design of appliances and machines. Professor ALBERT.

3D59. *Special Investigations in Machine Design.* Each term. Credit as arranged. Opportunity is offered to qualified students, individually or in small groups, to pursue, under direction, special investigations in machine design and related fields. Professors ALBERT, ROGERS, BLACK, or JOHNSON.

### ENGINEERING MATERIALS

(See courses under the letter T)

### EXPERIMENTAL MECHANICAL ENGINEERING

(See the courses listed under the letter X)

### GENERAL COURSES (G)

3G11. *Introductory Lectures.* Normally given to first term students. Credit one hour. One lecture a week. This course of lectures is designed to introduce the student to the various fields of engineering, and to demonstrate to them some of the simpler and more general methods of engineering construction. It is the purpose of the lectures to awaken the interest of the freshmen in their chosen profession through the aid of vivid description, of stimulating biography, and of personal experience.

3G41. *Non-resident Lectures.* Normally for seniors in Mechanical and Administrative Engineering. These lectures are given mostly by eminent non-resident practicing engineers or executives at some hour in the day specially set aside each week in the senior schedules.

3G51. *A. S. M. E. Student Branch.* Students who have completed at least two terms in Administrative or Mechanical Engineering are urged to become members of the Student Branch of the American Society of Mechanical Engineers, the meetings of which, however, are open to all. Attendance at any fourteen Branch meetings entitles the member to one hour elective credit. Applications for membership should be made at the Director's Office in October of each year, or to the Honorary Chairman of the Student Branch, Assistant Professor G. LEE.

### HEAT POWER ENGINEERING

(See the courses listed under the letter P)

### INDUSTRIAL ENGINEERING (I)

3I43. *Industrial Engineering.* Alternate terms. Credit three hours. One lecture and two laboratory periods a week. Required of all Administrative

Engineers and of Mechanical Engineers electing the Industrial Option. The laboratory work consists mainly of a study built around a case problem which concerns, in a specific and detailed manner, the location and layout of a factory for the production of automobile transmissions, supplemented with problems on materials handling equipment, time and motion study, plant organization, etc. The lectures cover the major features of modern industry as well as specific problems concerning the laboratory work. Associate Professor MILLARD and Mr. MABIE.

3I44. *Industrial Engineering.* Alternate with 3I43. Credit three hours. One lecture and two laboratory periods a week. Prerequisite course 3I43. Required of all Mechanical Engineers electing the Industrial Option. Elective for seniors. A series of typical industrial problems dealing with modern production, such as machine rate, production and materials control, wage payments, equipment selection, work simplification, etc. For the most part these problems are based on the work done in course 3I43. Assistant Professor MILLARD and Mr. MABIE. (Temporarily discontinued.)

3I48. *Industrial Engineering Economy.* Credit two hours. Two recitation and discussion periods a week. Prerequisite courses 3I43 and 3A31 or its equivalent. Required of all Mechanical Engineers electing the Industrial Option. Elective for seniors. A consideration of problems in engineering economy is approached by the question, "Will it Pay?" Associate Professor MILLARD and Mr. MABIE.

3I51. *Advanced Industrial Engineering.* Elective. Any term. Credit one hour for forty hours of actual work. Open to a limited number of seniors and graduates. Special problems and investigations which are carried on under the direction of members of the department staff. Associate Professor MILLARD and Mr. MABIE.

3I52. *Industrial Auditing.* Elective. For seniors and graduates. Alternate terms. Credit two hours. One lecture and one computing period a week. Prerequisite course—Accounting for Engineers 3A31 or its equivalent. A study of auditing theory and practice by the use of illustrative problems pertaining to manufacturing concerns. Associate Professor MILLARD.

3I54. *Motion and Time Study.* Required of A.E. seniors in M.E. Elective for others. Either term. Credit two hours. One recitation and one 2½-hour laboratory period each week. Prerequisite Courses 3A35 or 3A23. The course consists of four major parts: (1) Process Charts, (2) Time Study, (3) Motion Study, and (4) Micro-Motion Analysis. The fundamentals of each of these parts are thoroughly covered in the recitations, while the laboratory, which is co-ordinated with the recitations, is devoted to practical applications. All types of process charts are made. Time studies are taken in the laboratory as well as in the shop. Motion economy is studied by the development of a specific problem in the laboratory during which motion pictures are taken and the operations studied. Through the use of micro-motion analysis of these pictures, an improved method of performance is developed which leads to the final result as represented by a simo-motion chart. Associate Professor MILLARD and Mr. MABIE.

MACHINE DESIGN

(See the courses under the letter D)

MATERIALS OF ENGINEERING

(See the courses under the letter T)

MATERIALS PROCESSING

(See the courses under the letter S)

MECHANICAL LABORATORY

(See the courses under the letter X)

MECHANICS OF ENGINEERING (M)

3M21. *Theoretical and Applied Mechanics.* Third-term students. Credit five hours. Five recitations a week. Prerequisites, passing grades in Mathematics 55a and 55b or in 60a and 60b. Principles of Statics; forces and couples in a plane and in space; virtual displacements; applications to structures and mechanisms. Principles of Dynamics; analysis of translational and rotational motion of particles and rigid bodies; velocity, acceleration, momentum, impulse, work and energy, with engineering applications. Professor CORNELL, Assistant Professors PERKINS, LEE, and THOMSON, Messrs. LANG, MANSKY, and ANDREASSEN.

3M22a. *Strength of Materials.* Credit three hours. Prerequisite course 3M21. Stress, strain; strength and elastic properties of materials in tension, compression and shearing; riveted joints; torsion of shafts; helical springs; shear, moment, safe loading, and deflection of simple beams; special beams; eccentric loads; columns; impact loads. Professors CORNELL, GOODIER, Assistant Professors PERKINS, LEE, and THOMSON, Messrs. MANSKY, LANG, and ANDREASSEN.

3M22b. *Strength of Materials.* Credit two hours. A continuation of course 3M22a. Continuous beams; combined stresses; principal stresses; Mohr's circle of stress; theories of failure; thick walled cylinders; curved bars; unsymmetrical bending. Professors GOODIER and CORNELL, Assistant Professors PERKINS, LEE, and THOMSON, and Messrs. LANG, MANSKY, and ANDREASSEN.

3M24. *Applied Mathematics.* Credit three hours. Prerequisite course 3M21. Three recitations a week. Manipulation of data and reduction to empirical equations; elementary differential equations and applications to a variety of engineering problems, including free and forced vibration of the simpler mechanisms and structures. Professor GOODIER, Assistant Professors PERKINS, LEE, and THOMSON, and Mr. LANG.

3M25. *Theoretical and Applied Mechanics.* (For Chemical Engineers). Credit three hours. Three recitations a week. Prerequisites, Mathematics 60a, b and c. Statics in a plane and in space; dynamics of particles and rigid bodies. Conditions of equilibrium of force systems, application to simple structures. Friction. Center of Gravity. Velocity and acceleration. Newtonian laws of motion. Moments of inertia. Translation and rotation of rigid bodies.

3M26. *Mechanics and Strength of Materials.* (For Chemical Engineers). Credit three hours. Three recitations a week. Prerequisite course 3M25.

General plane motion of rigid bodies. Work and energy, linear and angular impulse and momentum, for particles and rigid bodies. Mechanical vibration of simple systems. Simple gyroscopic problems.

Analysis of stress and strain. Riveted and welded joints. Bending of beams. Statically indeterminate beams. Beams of variable cross-section. Beams of two materials, including reinforced concrete.

3M27. *Strength of Materials.* (For Chemical Engineers). Credit three hours. Three recitations a week. Prerequisite course 3M26. Combined tension and compression. Columns. Torsion. Strain energy and sudden loading. Thin circular plates, cylindrical and spherical shells. Thick-walled cylinders and spheres. Stress concentration at holes, notches, and other structural discontinuities.

3M54. *Advanced Engineering Mathematics.* Any term. Credit 3 hours. Prerequisite 3M24 or equivalent. Elective, juniors, seniors and graduates. An introduction to the mathematics used in the solution of advanced engineering problems. Partial differentiation. Line and surface integrals. Ordinary differential equations, power series solutions. Fourier series. Fourier integrals. Partial differential equations. Mr. CARRIER.

3M55. *Photoelasticity.* Elective for seniors and graduates. Credit two hours. One lecture and one laboratory-lecture period each week. Prerequisite course 3M22b. Optics of photoelasticity; plane and circularly polarized light, monochromatic and white light, fringes, isochromatics and isoclinics; discussion of models, materials, and preparation. Elements of elasticity, including equilibrium and compatibility equations for plane stress, and stress functions; methods for determining principal stresses from photoelastic observations and computations, isopachics. In the laboratory, experiments on the calibration of color and fringe scales by tension, compression, and bending, are followed by tests on centrally loaded beams, and the determination of stress concentration factors and the separation of principal stresses. Assistant Professor LEE. (Temporarily discontinued.)

3M56, 3M57. *Applied Elasticity.* Elective for graduates and qualified undergraduates. Continuing two terms. Credit three hours each term. Three lectures a week. Prerequisites, 3M22a, 3M22b, 3M24 or 224-A, or Mathematics 200 or Mathematics 70. General theorems of the elastic solid, reciprocal theorem, sudden loading; tension, flexure and torsion of bars of arbitrary section; Castigliano's theorem with application to frames, rings loaded in and normal to plane, spiral and helical springs; stress in thick cylinders and discs due to pressure, heating, and rotation; beams on elastic foundations; symmetrical deformation of thin tubes; propagation of stress waves in bars.

In the second term, the topics are chosen from: Thermal stress; stress-analysis, stability and vibration of plates and shells; vibration of beams. Professor GOODIER.

3M58. *Mechanics of Vibration.* Elective for seniors and graduates. Credit three hours. Prerequisite, Course 3M24. The characteristic phenomena of mechanical vibrations encountered in engineering, and their quanti-

tative investigation, illustrated by a group of typical vibrating systems. Representation of simple harmonic motion. Combination of several simultaneous motions. Simple cases of free and forced vibrations, with damping. Resonance. Principles of transmission and isolation of vibration. Systems of variable mass and variable elasticity. Vibrations of taut wires, bars, beams, rings, membranes. and plates. Relation of vibration and noise. Detection and measuring instruments. Examples of diagnosis and preventive measures. Professor GOODIER.

3M59. *Seminar in Applied Mechanics.* Elective for graduates (undergraduates by special permission). Each term. Credit, one hour each term. One discussion period each week. Prerequisites 3M56 and 3M57 or equivalents. Current research papers in applied mechanics reported and discussed by members of the group. Professor GOODIER.

3M60. *Theory of Elastic Stability.* Elective for seniors and graduates. Alternate terms. Credit three hours. Prerequisite course 3M22a, b, 3M24, or equivalents. Mathematical analysis of the conditions under which columns, beams, rings, tubes, thin plates, and thin curved shells may fail by general or local buckling. Applications to mechanical, civil, naval, and aeronautical structures. Professor GOODIER.

3M61. *Advanced Fluid Mechanics.* Elective for seniors and graduates. Alternate terms. Credit three hours. Prerequisite courses C.E. 6 and 3M24, or equivalents. The general problems of fluid mechanics. Dimensional analysis and similarity. The differential equations of hydro- and aero-dynamics. Bernoulli's equation. The theory of vortices. Lift and drag of airfoils. Effects of compressibility. Shock Waves. Motion of viscous fluids. Theory of lubrication. Professor GOODIER and Mr. KOCH.

### HEAT-POWER ENGINEERING (P)

3P35. *Heat-Power Engineering.* Credit three hours. Required of fifth-term students in Administrative, Chemical, Electrical, and Mechanical Engineering. Prerequisites 3D25, 3D26, 3M21, and 3M22a, or their equivalent. Three recitations a week. Basic thermodynamics of gases and vapors; ideal cycles and their application in air compressors, internal-combustion motors, steam engines and turbines; efficiencies and performances. Associate Professor HOOK, Assistant Professor B. J. CONTA, and Mr. GAY.

3P36. *Heat-Power Engineering.* Credit three hours. Required of sixth-term students in Administrative, Chemical, Electrical, and Mechanical Engineering. Prerequisite 3P35 or its equivalent. Three recitations a week. Flow of fluids through nozzles, orifices, and turbines; steam-turbine types, and their applications; heat transfer; fuels; combustion; steam-generating units; exit gas analysis; furnaces; boilers; stokers; and other fuel-burning equipment. Professors ELLENWOOD, CLARK, and B. J. CONTA.

3P43. *Heat-Power Equipment.* Required of all seniors in Civil Engineering. Alternate terms. Credit three hours. Not open to students in Mechanical or Electrical Engineering. Prerequisite courses, Physics 11 and 12 (or the equivalent), Chemistry C1a, C2a, C.E. 220 and 221. Two lectures and one two-hour period used for laboratory, inspection, computing, or

quiz purposes. Basic consideration of the behavior of gases and vapors as applied to heat engines; also the operation, maintenance, application, performance, first cost, and operating cost of air compressors, compressed air equipment, internal-combustion engines of both the carburetor and the compression-ignition types, steam boilers, engines, and turbines. Mr. GAY.

3P44, 3P45. *Steam and Oil-Engine Power Plants.* Required of Mechanical Engineering seniors in Option A. Two lectures a week. Two terms. Credit two hours a term. Prerequisite courses 3D37, 3D38, 3P35, and 3P36; must be accompanied by courses 3P46 and 3P47, and accompanied or preceded by courses 3P41 and 3P42. Performance characteristics and design features of steam prime movers, steam generators, condensers, feedwater heaters, evaporators, deaerators, oil engines, pumps, fans, and cooling towers; power-plant piping; automatic control; power-plant instruments, fuel-burning equipment; coal- and ash-handling equipment. Assistant Professor WRIGHT. (Temporarily discontinued.)

3P46, 3P47. *Power Plant Computing and Design.* Required of Mechanical Engineering seniors in Option A. Two computing periods a week. Credit two hours a term. Must be accompanied by 3P44 and 3P45. Energy balances; plant layouts; piping layouts; selection of equipment for central stations and industrial power plants. Assistant Professor WRIGHT. (Temporarily discontinued).

3P48. *Heating, Ventilating, and Air Conditioning.* Required of all seniors in Mechanical Engineering except those electing Option B. Any term. Credit three hours. Principles and practice in the conditioning of air, including cooling, heating, dehumidifying, and ventilating. Professor MACKEY. (Temporarily discontinued.)

3P49. *Refrigeration.* Elective for seniors. Required in Option B. Alternate terms. Credit two hours. Prerequisite course 3P36. Two lectures or recitations a week. A course dealing with the general principles, applications, and economic and commercial factors involved in various forms of modern refrigeration as applied to both domestic and industrial installations, including those pertaining to air conditioning. Professor ELLENWOOD. (Temporarily discontinued.)

3P50. *Power Plant Economics; Equipment Selection.* Elective for seniors. Alternate terms. Credit two hours. Prerequisite courses 3P35, 3P36. Two lectures a week. Cost of equipment and plants; energy costs; load curves, station factors; determining characteristics of equipment: selection of working pressures and temperatures and cycles; proper load distribution; economic number and size of units; selection of equipment based on these and other determining considerations; economic operation. Applications to central stations and to industrial power and heating plants. Other similar topics. Assistant Professor WRIGHT. (Temporarily discontinued.)

3P51. *Steam Turbines.* Elective for seniors. Alternate terms. Credit two hours. Prerequisite courses 3P35, 3P36, or equivalent. Two lectures a week. Classification of turbines and description of leading features of the various types; mechanical and thermal considerations underlying the action of steam in turbines; calculations involved in turbine design; dis-

cussion of building, erecting, and testing; adaptability to special conditions of service; economic results of the use of turbines in engineering practice. Assistant Professor CLARK.

3P55. *Graphical Computation and Representation.* Elective for all except freshman. Alternate terms. Credit two hours. Slide rules; construction of net work charts and alignment charts for the solution of equations; and derivation of empirical equations from experimental curves. Assistant Professor WRIGHT.

3P57, 3P58. *Heat Engineering.* Throughout the year. M.E. seniors in Option B. Credit four hours a term. Must be accompanied or preceded by 3P82. Properties of mixtures, dimensional analysis, fluid flow, heat transmission, selection of fans and pumps, and refrigeration; applications to problems in air conditioning. Professor MACKEY. (Temporarily discontinued.)

3P61, 3P62. *Advanced Heat-Power Engineering.* Elective for advanced students. Continuing two terms. Credit two hours a term. Two recitations a week. Consideration of advanced problems dealing chiefly with steam-power plants. Professor ELLENWOOD.

3P63. *Advanced Thermodynamics.* Elective for advanced students. Alternate terms. Credit two hours. Two recitations a week. Prerequisite, permission of instructor. The Carnot Principle; temperature scales; entropy; the state properties of a substance, their experimental determination and correlation; equations of state; kinetic theory of gases; mixtures of ideal gases; special topics in mathematics will be considered as needed. Assistant Professor WRIGHT. (Temporarily discontinued.)

3P70. *Advanced Heat-Power Engineering Research.* Elective for graduate students and others qualified for advanced study in this field. Work and credit as arranged with Professors ELLENWOOD and other members of the department.

3P81. *Internal-Combustion Engines.* Required of all seniors in Mechanical Engineering and Administrative Engineering. Credit three hours. Prerequisites, 3P35 and 3P36 or their equivalent. The principles of operation of spark- and compression-ignition, internal-combustion engines and their auxiliaries; petroleum fuels and their properties; combustion; detonation and octane rating; engine cooling, rating, and performance; supercharging of aircraft and compression-ignition engines; gas turbine cycles. Assistant Professors B. J. CONTA, WRIGHT, and Mr. GAY.

3P82. *Steam-Power Plants.* Credit three hours. Required of all seniors in Mechanical Engineering. Prerequisites, 3P35, 3P36, or their equivalent. A review of the thermodynamics of vapors is followed by a further study of combustion and combustion-control equipment, draft apparatus; boilers, condensers, evaporators, feedwater heaters, feed pumps, economizers, and air preheaters; turbines, and plant auxiliaries; performance and cost of steam engines, turbines, and plants. Professor ELLENWOOD and Assistant Professors CLARK and WRIGHT.

3P88. *Refrigeration and Air Conditioning.* Required of all seniors in Mechanical Engineering. Three periods a week. Credit three hours. Prerequisites 3P35, 3P36, or their equivalent. The general principles of re-

frigeration with particular emphasis on the equipment; principles and practice in the conditioning of air, including cooling, heating, dehumidifying, and ventilating; application of refrigeration in cold storage. Assistant Professor WRIGHT

MATERIALS PROCESSING (S)

3S11. *Metal Working.* Freshmen. Credit one hour. Each term. One laboratory period a week. Hot-working processes and methods of joining: demonstrations and discussions of rolling, extrusion, drawing, and forging methods; practice in hand forging, forge welding, hardening and tempering; demonstrations followed by practice in oxy-acetylene welding and cutting, atomic hydrogen and electric welding. Also a study of mechanical fastenings. Assistant Professors CARRUTHERS and GEER and Messrs. HILL and MORGAN.

3S14. *Casting Processes.* Freshmen in Electrical Engineering. Credit one hour. Each term. One laboratory period a week. Coordinated instruction in foundry practice and pattern design and construction. Survey of casting methods including demonstrations of die casting and permanent mold casting. Practice in sand molding and core making followed by instruction in the design and practice in making patterns. Assistant Professors CARRUTHERS and GEER and Messrs. PATTERSON, CURTIS, and YAWGER.

3S15. *Casting Processes.* Freshmen in Mechanical Engineering. Credit two hours. Each term. Two laboratory periods a week. Includes all of course 3S14 and the following: study of sands, sand testing, and sand handling, machine molding, cupola and electric furnace operation, non-ferrous melting and founding, and study of continuous systems in production. Assistant Professors CARRUTHERS and GEER and Messrs. PATTERSON, CURTIS, and YAWGER.

3S16. *Casting Processes.* Credit one hour. Each term. One laboratory period a week. For students who have completed 3S14, or the equivalent, and desire to have the additional instruction offered in 3S15. Assistant Professors CARRUTHERS and GEER, and Messrs. PATTERSON, CURTIS, and YAWGER.

3S23. *Machine Tool Processes.* Credit two hours. Each term. Two laboratory periods a week. Prerequisite courses: 3S11 and 3S14 or 3S15. Fundamentals of machine tools and cutting tools. Study of machine tool design as related to modern tools and methods. Demonstrations and practice of the basic operations including gear-cutting methods. Operation and use of jigs and other manufacturing fixtures. Demonstrations and study of cold rolling, drawing, spinning, and punch and die operations. Plastics. Assistant Professors CARRUTHERS and GEER, and Mr. MACK.

3S24. *Measuring Instruments.* Credit one hour. One laboratory period a week. Prerequisite courses: 3S11, and 3S14 or 3S15. Must be accompanied by or preceded by 3S23. Study of types of gauges and measuring instruments and their applications; jigs, fixtures, and demonstrations of their use. Assistant Professors CARRUTHERS and GEER.

3S50. *Advanced Materials Processing.* Work and credit as arranged with Assistant Professors CARRUTHERS and GEER.

ENGINEERING MATERIALS (T)

3T21. *Engineering Materials.* Credit 3 hours. Prerequisite Chemistry C1a, 2a. An elementary lecture course in Engineering Materials covering the metallurgy of iron and steel, the constitution of metals and alloys, the metallography of iron and steels, alloy steels, non-ferrous metals and alloys. Associate Professor JEFFREY.

3T22. *Engineering Materials.* Credit 3 hours. Prerequisite 3T21. An elementary lecture course in Engineering Materials covering corrosion, fuels and their combustion, refractories, cementing materials and concrete, wood, rubber, plastics, lubricants, and the testing and inspection of materials. Associate Professor JEFFREY.

3T31. *Engineering Materials Laboratory—Metals and Alloys.* Credit 3 hours. Prerequisites 3T21 (or Chem. E. 755), 3M21, 3M22a, but may be taken simultaneously with the latter course. A laboratory course dealing with materials testing and the properties of metals and alloys. The following types of tests with testing machines and auxiliary apparatus will be performed: tension, torsion, compression of blocks and columns, bending, impact, fatigue, hardness and ductility. The relation between the properties, structure, selection, inspection and use of metals and alloys will be shown by the following experiments: carbon steels, cast irons, heat treatment, metal processing, non-ferrous metals and alloys, and metallography. Associate Professor MOYNIHAN, Assistant Professor EHRHART and Messrs. BOEHMER, C. R. OTTO, and YOUNG.

3T32. *Engineering Materials Laboratory—Non-Metallic Materials.* Credit 3 hours. Prerequisite 3T22 or 3T31. A laboratory course dealing with the properties, selection and use of the following non-metallic materials: oils and lubricants, fuels (solid, liquid, and gaseous) and combustion, plastics, wood, cementing materials and concrete. Associate Professor MOYNIHAN, Assistant Professor EHRHART, and Messrs. BOEHMER, C. R. OTTO, and YOUNG.

3T51. *Engineering Materials Research.* Credit 1 hour for forty hours of work. Prerequisites 3T31, 3T32. Open to a limited number of seniors and graduate students who have shown a proficiency in this field. Special problems and investigations are carried on under staff supervision. Associate Professors JEFFREY and MOYNIHAN, Assistant Professor EHRHART.

3T52. *Applied Physical Metallurgy.* Credit 3 hours. Elective. Prerequisite 3T31. This course covers the applications of physical metallurgy to problems in engineering. This will include all processing operations including casting, mechanical working and heat treatment, and the subsequent inspection and use of ferrous and non-ferrous metals and alloys. The significance and control of mechanical properties will be emphasized. Associate Professor JEFFREY.

MECHANICAL ENGINEERING LABORATORY (X)

3X40a. *Introductory Mechanical Laboratory.* Each term. Credit 3 hours. Normally for seventh-term students. May be substituted for 3X32. For those who have studied the properties of steam or are starting to do so. Eight experiments selected from the following: temperature measurement,

pressure measurement and control, steam calorimetry, indicators and planimeters, fluid flow, flue gas analysis and boiler water conditioning, dynamometers, hydraulic flow measurements, steam engine, carburetion and ignition. Professor MACKEY, Assistant Professor ANDRAE, Dr. DROPKIN, and Mr. PUTNAM.

3X40b. *Introductory Mechanical Laboratory.* Normally for seventh-term students. Each term. Credit 4 hours. Prerequisites same as for 3X40a. Ten experiments listed under 3X40a. Same staff as for 3X40a.

3X41. *Mechanical Laboratory.* Normally for eighth-term students. Each term. Credit 4 hours. Prerequisite: 3P40a. Ten experiments: combustion studies, blower test, boiler test, centrifugal pump test, Diesel engine test, automotive engine performance, refrigeration, steam turbine test, air flow measurements, water turbine test. Professors MACKEY, GAGE, and SAWDON and Assistant Professor L. L. OTTO.

3X51. *Experimental Engineering Research.* Elective. Any term. Credit one hour for forty hours of actual work. Open to a limited number of students who have available at least one laboratory period a week and who have shown proficiency in engineering subjects. Special problems and investigations which are in general carried on in the laboratories under the immediate direction of the members of this department. Professors MACKEY, SAWDON and GAGE, Assistant Professors ANDRAE, DROPKIN, and L. L. OTTO, and representatives of the department in which the student is taking his major work.

3X53. *Temperature Measuring Instruments.* Elective for seniors and graduates. Each term. Credit two hours. One laboratory-lecture period each week. Theory, construction, calibration, and application of: liquid-in-glass thermometers, solid expansion thermometers, pressure-spring thermometers, electrical resistance thermometers, thermocouples, optical pyrometers and radiation pyrometers. Dr. DROPKIN. (Temporarily discontinued.)

### SHOP WORK

(See the courses under letter S)

## ELECTRICAL ENGINEERING

405a, 406a. *Fundamentals of Electrical Engineering, Theory.* Required of fifth- and sixth-term students in Mechanical Engineering and Administrative Engineering. Two terms. Credit three hours a term. Two lectures and one recitation each week. Prerequisite courses, Physics 11, 12, and Mechanics 3M21.

*First term:* D-c. electric and magnetic circuits; principles of d-c. motors, generators, and control equipment; electrical power distribution; simple a-c. circuits.

*Second term:* A-c. circuits, measurements and machinery; industrial applications. Professor STRONG, Assistant Professors COTNER, MESERVE, and H. G. SMITH.

405b, 406b. *Fundamentals of Electrical Engineering, Laboratory.* Required of fifth- and sixth-term students in Mechanical Engineering and

Administrative Engineering. Two terms. Credit one hour a term. One laboratory period each week. Laboratory work to accompany courses 405a, 406a. Professor AGER, Assistant Professors CREDLE and J. H. SMITH, Messrs. LANGENWALTER and STALLMAN.

407a, 408a. *Fundamentals of Electrical Engineering, Theory.* Required of seventh- and eighth-term students in Chemical Engineering. Two terms. Credit three hours a term. Two lectures and one recitation each week. Prerequisite courses, Physics 11, 12 and Mechanics 3M21.

Similar content to courses 405a, 406a, but designed for the needs of Chemical Engineering students. Professor STRONG, Assistant Professors COTNER, MESERVE, and H. G. SMITH.

407b, 408b. *Fundamentals of Electrical Engineering, Laboratory.* Required of seventh- and eighth-term students in Chemical Engineering. Two terms. Credit one hour a term. One laboratory period each week. Laboratory work to accompany courses 407a, 408a. Professor AGER, Assistant Professors CREDLE, and J. H. SMITH, Messrs. LANGENWALTER and STALLMAN.

410. *Elements of Electrical Engineering.* Required of fourth-term students in Electrical Engineering. Credit four hours. Prerequisite courses Physics 11, 12, 21 or NPH1, NPH2, NEE1; Mathematics 60a, 60b, 60c, or NM5, 6; Mechanics 3M21. One lecture, two recitations, and a computing period each week. An introductory study of electrical phenomena and their application to engineering. Aims to provide a solid foundation for further study in electrical engineering. Professor STRONG, Assistant Professors COTNER, MESERVE, H. G. SMITH.

411. *Alternating-Current Circuits.* Required of fifth-term students in Electrical Engineering. Credit three hours. Prerequisite courses, Electrical Engineering 410 and Engineering Mathematics 480 or Mathematics NM7. One lecture, one recitation, and one computing period each week. A thorough study of alternating-current circuit fundamentals. Use of complex quantity representation in solving circuit problems. Professor STRONG, Assistant Professors COTNER, MESERVE, H. G. SMITH.

412. *Alternating-Current Machinery.* Required of sixth-term students in Electrical Engineering. Credit four hours. Prerequisite courses, Electrical Engineering 411, 413. One lecture, two recitations, and one computing period each week. Application of fundamental circuit concepts to alternating-current machinery. Study of synchronous generators, synchronous and induction motors and transformers. Professor STRONG, Assistant Professors COTNER and GROSS.

413. *Direct-Current Machinery.* Required of fifth-term students in Electrical Engineering. Credit two hours. Prerequisite course, Electrical Engineering 410. One lecture and one recitation or computing period each week. A study of the theory and operation of direct-current generators, motors and control. Professor STRONG and Assistant Professor MESERVE.

418. *Electrical Equipment.* Required of seventh- or eighth-term students in Civil Engineering. Credit three hours. Prerequisite, Physics 11, 12 and Mechanics CE220, 221. Two lectures and one laboratory or computing period each week. A study of the fundamental physical principles of elec-

trical engineering, and their application in the common types of electrical equipment, to enable the student to select the proper type of apparatus for the services met in ordinary practice. Professor BALLARD, Assistant Professors GROSS and J. H. SMITH.

421. *Advanced Alternating-Current Machinery.* Required of seventh- or eighth-term students in Electrical Engineering, Power Option. Credit three hours. Prerequisite courses, Electrical Engineering 412, 431, 432. Three lecture-recitation periods each week. Advanced treatment of alternating current generators, motors, and transformers. Such topics as armature reactance and reaction, two-reaction theory, and the effects of saturation in synchronous machines are treated in detail. Associate Professor MANNING.

422. *Electrical Insulation and High Voltage Practice.* Required of eighth-term students in Electrical Engineering. Credit three hours. Prerequisite courses, Electrical Engineering 410, 411, 431, 432. Two and three dimensional electric fields, analytical and graphical methods. Electric stress. Insulating materials. Dielectric breakdown of solid, liquid, and gaseous insulation. Corona. Associate Professor MANNING.

423, 424. *Advanced Electric Circuit Theory.* Required of seventh- and eighth-term students in Electrical Engineering. Two terms. Credit two hours a term. Prerequisite courses, Electrical Engineering 410, 411, 412, 431. Two recitations each week. The work of the first term extends the treatment of dimensional analysis, Fourier series, and other topics introduced in courses 411 and 480, and covers circuits with variable characteristics, coupled circuits, and non-sinusoidal currents. The second term is devoted to balanced and unbalanced polyphase circuits, symmetrical components, electric transients, filter circuits, and ladder networks. Professor MALTI.

431. *Electrical Laboratory.* Required of fourth-term students in Electrical Engineering. Credit three hours. Prerequisite courses Physics 21 or NEE1, and must be accompanied or preceded by 410. One recitation and one laboratory period each week. Experimental work on elementary electrical circuits and electrical measurements. Professor BURCKMYER, Messrs. ANKRUM, and SCHAUSS.

432. *Electrical Laboratory.* Required of fifth-term students in Electrical Engineering. Credit two hours. Prerequisite courses Electrical Engineering 410, 431 and must be accompanied or preceded by 411 and 413. One recitation and one laboratory period each week. Experimental work on alternating-current circuits and direct-current machinery. Professor AGER.

433, 434. *Advanced Electrical Laboratory.* Required of sixth- and seventh-term students in Electrical Engineering. Two terms. Credit four hours a term. Prerequisite courses, Electrical Engineering 412, 432. Two recitations and one laboratory period each week. Laboratory technique and instrumentation. Tests on rotating machinery, transformers, and other apparatus. Professor BURCKMYER, Messrs. ANKRUM and SCHAUSS.

437, 438. *Advanced Electrical Laboratory.* Two terms. Credit two hours a term. Prerequisite courses, Electrical Engineering 412, 432. One recitation and one laboratory period each week. An abridgment of 433, 434. Professor BURCKMYER, Messrs. ANKRUM and SCHAUSS.

441. *Electrical Power Plants.* Required of seventh- or eighth-term students in Electrical Engineering, Power Option. Credit three hours. Prerequisite courses 411, 412, and 432 or equivalent. Two lecture-recitations and one computing period each week. A study of power station equipment, and its proper application and selection. Some attention is devoted to operating features, and to questions of economics, finance, and public policy. Assistant Professor GROSS.

451. *Electrical Communication Engineering.* Required of seventh-term students in Electrical Engineering, Communication Option. Credit three hours. Two lectures and one recitation period each week. Prerequisite courses, Electrical Engineering 411, 431, and 450 or NEE5b, and NEE6b. Consideration of the theory of alternating currents at high and ultra high frequencies, as applied to telegraph, telephone, radio and radar communication and signalling. Emphasis is placed upon the use of electronic devices. Professor BALLARD, Associate Professor MCLEAN, Mr. SEEGER.

452a. *Electrical Communication Engineering.* Required of eighth-term students in Electrical Engineering, Communication Option. Credit three hours. Two lectures and one recitation each week. Prerequisite courses 451, 4C53. Consideration of problems, apparatus, and measurements particularly applicable to electrical communication engineering and allied fields. Professor BALLARD, Associate Professor MCLEAN, and Mr. SEEGER.

453, 454. *Communication Networks.* Option for seventh- and eighth-term students in Electrical Engineering. Two terms. Credit two hours a term. Two recitations each week. Must be accompanied by 451, 452a, 4C53, 4C54a. Basic laws of elements and circuits with variable frequency. General Network Theorems. Two and four-terminal structures. Recurrent networks and wave filters. Equalizers, Distributed circuits including continuous and concentrated loading of long lines. Special networks for very high frequencies. Associate Professor MCLEAN.

451, 458. *Communication Laboratory.* Option for seventh- and eighth-term students in Electrical Engineering, Communication Option. Two terms. Credit one hour a term. One laboratory or computing period each week. Additional laboratory work to accompany NEE 7Lb, 8Lb. Problem work and the design and construction of communication equipment. Location and correction of troubles in commercial equipment. Professor BALLARD, Messrs. BECK and SEEGER.

463. *Electric Power Transmission.* Required of seventh- or eighth-term students in Electrical Engineering, Power Option. Credit three hours. Prerequisite courses, Electrical Engineering 411, 412, 431, 432. Two recitations and one computing period each week. A study of circuits with distributed parameters. Use of complex hyperbolic functions. General circuit constants and equivalent circuits. Circle diagrams and power limits. Assistant Professor GROSS.

465, 466. *Illumination.* Elective for students in fourth to eighth terms. Two terms. Credit two hours a term. Prerequisites, Physics 11 and 12, or equivalent. A study of the production, measurement, and utilization of light, with emphasis on the latter. Recitation, discussion, and problem work. Oral reports on illumination topics of current interest. Professor STRONG.

480. *Engineering Mathematics.* Required of fourth-term students in Electrical Engineering. Credit two hours. Prerequisite course, Mathematics 60c or equivalent. One lecture and one recitation each week. A further study of mathematical principles, devoted particularly to the needs of the electrical engineer. Complex numbers, determinants, solution of equations and elementary differential equations. Professor MALTI and Assistant Professor COTTRELL.

481. *Engineering Mathematics.* Required of fifth-term students in Electrical Engineering. Credit two hours. Prerequisite course, Electrical Engineering 480. One lecture and one recitation each week. A continuation of 480. Theory of equations, Fourier series, special functions used in electrical engineering. Professor MALTI and Assistant Professor COTTRELL.

483. *Special Electrical Engineering Problems.* Open to seventh- and eighth-term, and in special cases qualified fifth-and sixth-term students in Electrical Engineering. Credit one to three hours. Special problems to suit the needs of individual students, working under the personal supervision of the professor in charge. Each student selects his own problem, subject to the approval of the Director of the School of Electrical Engineering. Professors and instructors as required.

485, 486. *Operational Analysis.* Elective for seventh- and eighth-term and graduate students in Electrical Engineering. Two terms. Credit three hours a term. Prerequisite courses, Electrical Engineering 481, or equivalant, and must follow or be taken concurrently with 423, 424. Two lecture recitations and one computing period each week. Mathematical introduction covering functions of real and complex variables, infinite series, some special functions, integral equations, Fourier and LaPlace transforms. Generalized expansion theorems for differential and difference equations. Application to transient problems in circuits with lumped and distributed parameters, and to ladder networks. Professor MALTI.

4C53, 4C54a. *Communications Laboratory.* Required of seventh- and eighth-term students in Electrical Engineering, Communication Option. Two terms. Credit, first term three hours, second term four hours. One recitation and two laboratory or computing periods each week. Laboratory work to accompany 451 and 452a. Experimental work covering various types of high-frequency devices including triodes, magnetrons, klystrons and other tubes; transmission lines and wave guides, radiating systems, radio transmitters and receivers. Professor BALLARD, Associate Professor MCLEAN, Messrs. BECK and SEEGER.

## CHEMICAL ENGINEERING

### CHEMISTRY

110a, b. *Introductory Inorganic Chemistry.* Two terms. Credit three hours first term, two hours second term. Prerequisite, entrance credit in chemistry, or course 101. Required of candidates for the degree of Bachelor of Chemical Engineering. Lectures. Professor LAUBENGAYER.

115. *Introductory Inorganic Chemistry.* Recitations and laboratory practice. One term. Credit three hours. Must be taken with the first term

of Chemistry 110. Deposit, $20. Professor LAUBENGAYER and assistants. Recitations: one hour a week, to be arranged. Laboratory: to be arranged. *Baker* 50.

203. *Introductory Qualitative Analysis.* One term. Credit five hours. Prerequisite, one term of Chemistry 110 or special permission. Deposit, $30. Must be taken with the second term of Chemistry 110. Required of students in the course in Chemical Engineering. Professor NICHOLS, Dr. LONG, and assistants. One lecture, one recitation, and three laboratory periods a week.

220. *Introductory Quantitative Analysis.* Repeated each term. Credit three hours. Prerequisite, Chemistry 203, or 205 and 206. Must be taken with Course 221. Professor NICHOLS and assistants. Two lectures and one recitation a week.

A study of the fundamental principles of gravimetric and volumetric analysis with practice in stoichiometry.

221. *Introductory Quantitative Analysis.* Repeated each term. Credit three hours. Prerequisite, Chemistry 203, or 205 and 206. Must be taken with Course 220. Deposit, $25. Professor NICHOLS and assistants. Three laboratory periods a week.

Laboratory practice in the preparation and standardization of various volumetric solutions and the analysis of a variety of substances by volumetric and gravimetric methods.

305a, b. *Introductory Organic Chemistry.* Two terms. Credit six hours on completion of the course. Prerequisite, qualitative analysis. Open to those who are taking Course 220. Professor BLOMQUIST. Three lectures a week.

Lectures and written reviews. The more important compounds of carbon, their occurrence, methods of preparation, relations, and uses.

310a, b. *Introductory Organic Chemistry.* Two terms. Credit three hours a term. Prerequisite or parallel course, Chemistry 305. Deposit, $40. Professor BLOMQUIST and Mr. SWEETING, and assistants. Three laboratory sections a week.

Laboratory practice and oral reviews. The student prepares a large number of typical compounds of carbon and familiarizes himself with their properties, reactions, and relations.

405a, b. *Introductory Physical Chemistry.* Two terms. Credit three hours a term. Prerequisite, Chemistry 305, Mathematics 5a and 5b and Physics 11 and 12 (or their substantial equivalent). Professor BRIGGS and assistants. Three lectures a week.

A systematic presentation of modern physical chemistry. The topics include the properties of gases, liquids, and solids; physical and chemical equilibrium in homogeneous and heterogeneous systems; the Mass Law, theorem of Le Chatelier, and the Phase Rule; thermochemistry and elementary thermodynamics; the theory of solutions; ionic equilibria and the concept of activity; chemical kinetics and catalysis; photochemistry; written problems in physical chemistry.

410a, b. *Introductory Physical Chemistry.* Two terms. Laboratory and recitations. Credit three hours a term. Prerequisite or parallel course,

Chemistry 405. Deposit, $20. Professor BRIGGS, Professor ROBERTS, and assistants. Two laboratory periods and one recitation a week.

Qualitative and quantitative experiments illustrating the principles of physical chemistry and practice in performing typical physico-chemical measurements. Recitations on the general principles of physical chemistry, based upon the lectures given in Course 405.

420a, b. *Advanced Physical Chemistry.* Two terms. Credit three hours first term, two hours second term. Prerequisite, Chemistry 405. Professor ROBERTS. Lectures: three hours a week for first term, two hours a week for second term.

Exposition of the principles of physical chemistry from the mathematical standpoint, with emphasis on the solution of simple problems.

For description of other courses in Chemistry, available as electives in the course in Chemical Engineering, see *Announcement of the College of Arts and Sciences.*

## PHYSICS

For description of Physics courses 11 and 12, see pages 117 and 118 of this Announcement. For courses 21 and 22, see page 118 of this Announcement. For advanced courses in Physics available as electives, consult the *Announcement of the College of Arts and Sciences.*

## MATHEMATICS

60a, 60b, 60c. *Analytical Geometry and Calculus.* Credit three hours a term. Prerequisites, Solid Geometry and Trigonometry.

## MECHANICAL ENGINEERING

Those courses required for the degree of Bachelor of Chemical Engineering that are given in the School of Mechanical Engineering are described in the section of this announcement that is devoted to a discussion of the work in Mechanical Engineering.

## ELECTRICAL ENGINEERING

Courses 407 and 408 in Electrical Engineering are described on page 98 of this Announcement.

## ENGLISH

*English 2a, b.* Credit three hours a term. May not be entered the second term. The course is a training in reading and writing English. Registration is in charge of Director RHODES, Professor BROWN, and others.

## CHEMICAL ENGINEERING

530. *Introductory Chemical Miscroscopy.* Either term. Credit three hours. Prerequisite, or parallel course, Chemistry 405 or 406 and Physics 21 and 22, or special permission. Fee, $5. Professor MASON and assistants. Lecture, M 11, *Olin* R. Two laboratory periods, *Olin* 305.

Lectures and laboratory practice. The use of microscopes and their accessories in chemical and technical investigations. Micrometry; quantitative estimations; microscopical characteristics and physical chemistry of crystals; illumination, ultra-microscopy and photomicrography; study of industrial materials such as textile and paper fibres.

531. *Special Methods in Chemical Microscopy.* Either term. Credit one or more hours. Prerequisite, 530 and special permission. Fee variable. Professor MASON. Day and hour to be arranged. *Olin* 305.

Laboratory practice may be elected in various fields, such as photomicrography, ultra-microscopy, crystal studies, micro-manipulations, quantitative determinations, and the microscopy of industrial materials.

535. *Microscopical Qualitative Analysis (Inorganic).* Either term. Credit two or more hours. Prerequisite, Chemistry 530. Professor MASON. Laboratory periods to be arranged. *Olin* 305.

Laboratory practice in the analysis of inorganic substances containing the more common elements.

[540. *Microscopical Methods in Organic Chemistry.* Either term. Credit two or more hours. Prerequisites, Chemistry 530 and special permission. Professor MASON. Day and hour to be arranged. *Olin* 305.

Laboratory practice. General manipulative methods applicable to small amounts of material, crystallization procedure, determination of melting points and molecular weights, chemical tests and reactions for elements, radicals, and various types of organic compounds. Preparation of simple derivatives. Not given in 1944.]

545. *Introductory Metallography.* Alternate terms. Credit three hours. Prerequisite, 755 or 3X31. Fee, $10. Professor MASON and assistants Th F 1:40–4, additional M T 1:40–4 section is warranted. *Olin* 312A Lecture to be arranged.

Microstructures of alloys, as related to composition, thermal history, and physical properties and explained in terms of general crystallographic phenomena. Preparation of specimens, and principles and use of metallographic microscopes.

550a, b. *Advanced Metallography.* Lectures, credit two hours. Laboratory optional, credit one or more hours. Prerequisite, Chemical Engineering 545 and consent of the instructor. Laboratory fee variable. Professor MASON. *Olin* R and *Olin* 312A.

Lectures, conferences, and reports on various topics in physical metallurgy. Laboratory work, arranged in accordance with the interests of the student, covering heat treatment and structures of ferrous or non-ferrous alloys, or minor research problems.

The lectures of either 550a or 550b will be given alternately, in every alternate term, to constitute a cycle repeated every four terms. Either term may be taken separately.

701a, b. *Chemical Engineering Technology.* Consecutive terms. Credit two hours a term. Mr. KRANICH.

Lectures. A discussion of the important chemical engineering processes and industries. The first term is devoted to the consideration of inorganic chemical technology; in the second term, the discussion deals with the organic chemical engineering industries.

705a, b. *Unit Operations of Chemical Engineering.* Consecutive terms. Credit three hours a term. M W F 10. *Olin* B. Professor RHODES.

Lectures: A critical discussion of the unit operations of chemical engineering.

710a, b. *Unit Operations Laboratory.* Two terms. Credit two hours a term. Prerequisite, Chemistry 405. Fee, $10. Professor RHODES, Associate Professor SWENSON, Mr. BRANDSMA, and assistants. One laboratory period and one lecture a week.

The study in the laboratory, on a semi-plant scale, of the unit operations of chemical engineering, such as agitation and mixing, filtration, fractional distillation, evaporation, drying, absorption of gases, and heat transfer.

715. *Synthetic Resins and Plastics.* Alternate terms. Credit three hours. Prerequisite or parallel course, Chemical Engineering 705. Associate Professor WINDING. Lectures, M W F 9.

Polymerization reactions; manufacture and properties of synthetic resins, plastics, and rubbers.

720a, b. *Food Technology.* Credit two hours a term. Prerequisite, Chemistry 405. Assistant Professor GORTNER. Two lectures a week.

Course 720a deals primarily with the chemistry of the essential foodstuff elements: carbohydrates, fats, proteins, mineral elements, and vitamins. Course 720b is concerned with dehydration, freezing, and other methods of food processing and food preservation.

725. *Petroleum Refining.* Alternate terms. Credit three hours. Prerequisite, course 705. Associate Professor WINDING. Three lectures a week.

Processes employed in petroleum refining.

730a, b. *Chemical Plant Design.* Two terms. Credit three hours a term. Deposit, $20. Professors RHODES and MASON, Associate Professors SWENSON and WINDING, Assistant Professor GORTNER, Mr. KRANICH, and Mr. BRANDSMA. Times to be arranged.

Individual problems in the design of complete chemical plants.

740a, b. *Chemical Engineering Computations.* Two terms. Credit two hours a term. Prerequisite or parallel course, Chemical Engineering 705. Associate Professor WINDING.

Conferences and lectures. Problems in fluid flow and heat transfer, distillation, evaporation and drying, humidification and air conditioning, and filtration.

745. *Chemical Engineering Stoichiometry.* Two hours credit. Professor RHODES, Associate Professor WINDING, and Mr. KRANICH.

Lectures and recitations. Material balances and energy balances in chemical engineering; combustion reactions.

755a, b. *Materials of Construction.* Two terms. Credit two hours a term. Prerequisite or parallel course, Chemistry 405. Professor MASON. W F 11, *Olin* R.

Lectures. A discussion of the nature, behavior, and application of the important structural materials used in chemical engineering.

Required of students in Chemical Engineering.

760. *Chemical Engineering Instrumentation.* Alternate terms. Credit two hours. Prerequisite or parallel course, Chemical Engineering 705. Mr. KRANICH.

Lectures. Basic principles of instrumentation and process control. Applications of automatic indicating, recording, and controlling instruments in the process industries. Description of commercial types of instruments.

780a, b. *Chemical Engineering Equipment Design.* Credit two hours a term. Prerequisite course, Chemical Engineering 705. Associate Professor SWENSON.

Two lectures a week. Details of design and construction of chemical engineering equipment; piping, design of pressure vessels, detailed design of process equipment.

790. *Library Use and Patents.* Alternate terms. Credit one hour. Professors RHODES and MASON.

The effective use of technical literature; literature searches; abstracts and bibliographies; patent law.

791. *Chemistry of Explosives.* Alternate terms. Credit two hours. Professor RHODES. Two lectures a week. Open to officers of U. S. Navy only.

Manufacture and properties of primers, propellants, and high explosives.

792. *Interior Ballistics.* Alternate terms. Credit two hours. Professor RHODES. Two lectures a week. Open to officers of the U. S. Navy only.

795. *Research for Seniors.* Each term. Credit two or more hours a term. Fee variable. Professors RHODES and MASON, Associate Professors WINDING and SWENSON, and Assistant Professor GORTNER.

# NAVY V-12 COURSES

The following courses, conducted in accordance with the Navy V-12 outline, have been incorporated in one or more civilian curricula, and are therefore listed in the Announcement for civilian students.

## Civil Engineering

N.C.E. 6. *Fluid Mechanics.* Required for students in Mechanical and Electrical Engineering. Credit three hours. Text book: *Fluid Mechanics*, Cox and Germano. Two recitations and one laboratory period a week. Professor Schoder, Assistant Professor Bogema, and Mr. Priest.

Properties of fluids, gas laws, viscosity; static pressures, center of pressure on plane and curved surface; gages and manometers; buoyant force and equilibrium of floating and immersed bodies; dynamics of fluids, Bernoulli's theorem; impulse and momentum, open jets, vanes; flow in pipes, Reynolds' number, hydraulic gradient, divided flow; orifices, nozzles, weirs, and gates; open-channel flow; hydraulic similitude and dimensional analysis.

N.C.E. 14. *Water Supply.* Required of all students in Civil Engineering. Credit three hours. Prerequisite course 240 or N.C.E. 6. Text book: *Water Supply Engineering*, Babbitt and Doland. Two recitations and one computing period a week. Professor Walker and Assistant Professor Gifft.

Sources of water supply, quantity available, uses, and rates of demand. Quality, examination, treatment, and purification. Collection, storage, pumping, and distribution systems. Laboratory periods will include examination and reports on water supply systems, simple design problems, and cost estimates.

N.C.E. 16. *Airport Design.* Required of all V-12 students. Elective for others. Credit three hours. Prerequisite course 287 or N.C.E. 15.

The factors influencing the location, design, and construction of airports; passenger and express terminal facilities; hangars and accessory structures; field lighting; selection of type of runway, apron, and taxiway. Subgrades; design of base courses; flexible and rigid type pavements; surface and sub-surface drainage. Laboratory periods will be devoted to design problems. Two recitations and one laboratory period a week. Professor Malcolm.

N.C.E. 17. *Highway Engineering.* Required of all Civil Engineering students. Credit four hours. Prerequisite 260B or N.C.E. 10, and 287, or N.C.E. 15. Text book: *Highway Design and Construction*, Bruce. Three recitations and one laboratory period a week. Professor Malcolm.

Design, construction, and maintenance of highways and city streets. Location, alignment, drainage, width, and capacity; soils and soil stabilization; earth, gravel, and macadam roads; city and rural pavements; grade separations; minor structures; construction in swamps; construction methods and equipment; traffic control; planning surveys, economics, financing, and administration.

Laboratory periods will be devoted to testing of highway materials.

## Mechanical Engineering

NME3a. *Heat Power* 1a. Consists of NME3Th and NME3aLb.

NME3aTh. *Heat Power, Theory.* Required of sixth-term students in Electrical Engineering. Credit two hours. Prerequisite courses, Physics 12, Mechanics 3M21, and NME4a. Two lecture-recitation periods each week.

An abridged treatment of the use of thermodynamic principles by analyzing reciprocating and centrifugal gas compressor cycles, internal-combustion-engine cycles, steam engines, gas and vapor nozzles, steam and gas turbines; steam generators and condensers, refrigeration cycles and air-conditioning problems.

NME3aLb. *Heat Power, Laboratory.* Required of sixth-term students in Electrical Engineering. Credit one hour. To accompany NME3aTh. One laboratory period each week.

Laboratory work which includes tests and reports on the characteristics and performance of compressors, engines, nozzles, turbines, etc. Correlated as closely as possible with NME3aTh.

NME4a. *Thermodynamics* 1a. Required of fifth-term students in Electrical Engineering. Credit three hours. Prerequisite courses, Physics 12 and Mechanics 3M21. Three lecture-recitation periods each week.

An abridged treatment of the fundamental concepts and principles involved in the release, transfer, and conversion of thermal energy. Energy concepts and units; principle of conversion of energy; properties of gases, vapors, and mixtures. Combustion reactions; heat release; principles of heat transfer. Compression and expansion of gases and vapors; second law of thermodynamics; steady flow of fluids; the use of steam and gas tables.

## Electrical Engineering

NEE3. *Electric and Magnetic Circuits,* I. Consists of NEE3Th and NEE3Lb.

NEE3Th. *Electric and Magnetic Circuits,* I, *Theory.* Required of fourth-term students in Electrical Engineering. Credit four hours. Prerequisite courses, Physics 21 or NEE1. One lecture, two recitations, and one computing period each week.

Kirchhoff's laws; direct current networks; elementary transients; sinusoidal currents and voltages; electric and magnetic fields; eddy currents and hysteresis. Professor Strong, Assistant Professors Cotner, Meserve, and H. G. Smith.

NEE3Lb. *Electric and Magnetic Circuits,* I, *Laboratory.* Required of fourth-term students in Electrical Engineering. Credit one hour. To accompany NEE3Th. One laboratory period each week. Experimental work in the topics of NEE3Th. Professor Burckmyer, Messrs. Ankrum, and Schauss.

NEE4. *Electric and Magnetic Circuits,* II. Consists of NEE4Th and NEE4Lb.

NEE4Th. *Electric and Magnetic Circuits,* II, *Theory.* Required of fifth-term students in Electrical Engineering. Credit four hours. Prerequisite

courses, NEE3Th, 3Lb. One lecture, two recitations, and one computing period each week.

Complex number representation of alternating-current quantities; alternating-current networks; transmission lines and filters; polyphase circuits; Fourier series. Professor STRONG, Assistant Professors COTNER, MESERVE; and H. G. SMITH.

NEE4Lb. *Electric and Magnetic Circuits*, II, *Laboratory*. Required of fifth-term students in Electrical Engineering. Credit one hour. To accompany NEE4Th. One laboratory period each week. Experimental work in the topics of NEE4Th. Professor AGER.

NEE5, 6. *Electron Tubes and Circuits*, I, II. Required of seventh- and eighth-term students in Electrical Engineering, Power Option. Two terms. Credit, first term two hours, second term four hours. Prerequisites, to be accompanied or preceded by NEE3, 4. First term, one lecture and one laboratory period each week. Second term, three lecture-recitation periods and one laboratory period each week.

Electronic emission, cathodes, diodes, static and dynamic characteristics and rectification; rectifiers, power supplies and smoothing-circuits; static and dynamic characteristics of triodes, tetrodes, pentodes; amplifiers; oscillators; phototubes; glow and arc-discharge tubes and thyratrons; grid control action; mercury-arc and ignition rectifiers. Characteristics, current and voltage capacities and typical circuits. Professor BALLARD, Associate Professor NORTHROP, Assistant Professor COTTRELL.

NEE5b, 6b. *Electron Tubes and Circuits* Ib, IIb. Required of fifth- and sixth-term students in Electrical Engineering, Communication Option. Two terms. Credit, first term two hours, second term three hours. Prerequisites, to be accompanied by NEE3, 4. First term; one lecture and one laboratory period each week. Second term, two lecture-recitations and one laboratory period each week. A condensation of NEE5, 6; designed as a preparation for NEE7, 8. Professor BALLARD, Associate Professor NORTHROP, Assistant Professor COTTRELL.

NEE7, 8. *High-Frequency Circuits* I, II. Consists of NEE7Th, 8Th and NEE 7Lb, 8Lb.

NEE7Th, 8Th. *High-Frequency Circuits*, I, II, *Theory*. Required of seventh- and eighth-term students in Electrical Engineering, Communication Option. Two terms. Credit three hours a term. Prerequisite courses, NEE3, 4, 5b, 6b. Three lecture-recitation periods each week.

Resonance and four-terminal network theory, power rectification, amplification, oscillation; cathode-ray tubes and circuits; modulation, demodulation; receivers; transmitters; high-frequency generators; transmission lines and wave guides; radiation and propagation. Professor BALLARD, Associate Professor MCLEAN, and Mr. SEEGER.

NEE7Lb., 8Lb. *High-Frequency Circuits*, I, II, *Laboratory*. Required of seventh- and eighth-term students in Electrical Engineering, Communication Option. Two terms. Credit two hours a term. To accompany NEE7Th 8Th. One recitation and one laboratory period each week. Experimental work in the topics of NEE7Th, 8Th. Professor BALLARD, Associate Professor MCLEAN, Messrs. BECK and SEEGER.

NEE9(2/5). *Electrical Measurements*, I. Required of fourth-term students in Electrical Engineering. Credit two hours. To accompany or follow NEE3. One recitation and one laboratory period each week.

Electric and magnetic units and standards; direct-current measurements; theory and use of portable direct-current and alternating-current instruments. Measurements for resistance, inductance, capacitance, voltage and current. Professor BURCKMYER, and Messrs. ANKRUM and SCHAUSS.

NEE9(3/5). *Electrical Measurements*, II. Required of sixth-term students in Electrical Engineering. Credit three hours. Prerequisite course NEE4, and to accompany NEE13. Two recitations and one laboratory period each week.

Low-frequency and audio-frequency measurements; calibration of laboratory standards and of potentiometers, galvanometers, wattmeters, and watt-hour meters; theory, use and calibration of current transformers and potential transformers; magnetic flux density measurements and core loss in iron. Use of oscillographs. Measurements of reactance, impedance, power and power factor. Professor BURCKMYER, Messrs. ANKRUM, and SCHAUSS.

NEE12. *Direct-Current Machinery and Storage Batteries* I. Consists of NEE12Th and NEE12Lb.

NEE12a. *Direct-Current Machinery and Storage Batteries* Ia. Consists of NEE12aTh and NEE12aLb.

NEE12Th. *Direct-Current Machinery and Storage Batteries, Theory*. Required of fifth-term students in Electrical Engineering, Power Option. Credit four hours. Prerequisite courses, NEE3 and must accompany or follow NEE4. Three lecture-recitation periods and one computing period each week.

A study of direct-current motors, generators, motor-generator sets, and storage batteries, including their construction, operation, characteristics, and applications. Emphasis is placed on the theories of armature reaction, commutation, voltage regulation, and speed control of shunt and compound-wound machines. The theory and operation of starting, control, and regulating devices are covered. Professor STRONG and Assistant Professor MESERVE.

NEE12aTh. *Direct-Current Machinery and Storage Batteries, Theory*. Required of fifth-term students in Electrical Engineering, Communication Option. Credit two hours. Prerequisite courses, NEE3 and must accompany or follow NEE4. Two lecture-recitation periods each week. An abridgment of NEE12Th, suited to communication students. Professor STRONG and Assistant Professor MESERVE.

NEE12aLb. *Direct-Current Machinery and Storage Batteries, Laboratory*. Required of fifth-term students in Electrical Engineering. Credit one hour. Must accompany NEE12Th or 12aTh. One laboratory period each week. Experimental work on direct-current machinery, to accompany courses NEE12Th and 12aTh. Professor AGER.

NEE13. *Alternating-Current Machinery*, I. Consists of NEE13Th and NEE13Lb.

NEE13a. *Alternating-Current Machinery*, Ia. Consists of NEE13aTh and NEE13aLb.

NEE13Th. *Alternating-Current Machinery*, I, *Theory*. Required of sixth-term students in Electrical Engineering, Power Option. Credit four hours. Prerequisite courses, NEE4, 9 2/5, and 12. Four lecture-recitation periods each week.

Principles and advanced theory of synchronous generators, transformers, induction motors (poly-phase and single-phase), synchronous motors, synchronous converters and mercury-arc rectifiers, and their starting, control and regulating auxiliaries. Professor STRONG, Assistant Professors COTNER and GROSS.

NEE13aTh. *Alternating-Current Machinery*, Ia, *Theory*. Required of sixth-term students in Electrical Engineering, Communication Option. Credit three hours. Prerequisite courses, NEE4, 9 2/5, and 12a. Three lecture-recitation periods each week. An abridgment of NEE13Th, omitting mainly the advanced theory. Professor STRONG, Assistant Professors COTNER and GROSS.

NEE13aLb. *Alternating-Current Machinery, Laboratory*. Required of sixth-term students in Electrical Engineering. Credit one hour. Must accompany NEE 13Th or 13aTh. One laboratory period each week. Experimental work on alternating-current machinery, to accompany courses NEE13Th and 13aTh. Professor BURCKMYER, Messrs. ANKRUM and SCHAUSS.

NEE14. *Electrical Design*, I. Required of seventh or eighth-term students in Electrical Engineering. Credit three hours. Prerequisite courses NEE3, 4, 9 2/5, 12 or 12a, 13 or 13a. Two lecture-recitation periods and one computing period each week.

Field mapping, simple two-dimensional cases; electromagnetic devices; magnetic circuits and magnetization curves; rewinding of machines for different conditions. Principles of design of transformers and of rotating alternating-current machinery are covered briefly. Design factors of influencing losses and heat dissipation are studied. Instruction is given in analysis of faults and in emergency repair work. Associate Professor MANNING.

NEE15. *Electrical Engineering Laboratory*. Required of seventh-term students in Electrical Engineering. Credit three hours. Prerequisite courses, NEE3, 4, 9, 12 or 12a, 13 or 13a. Two lecture-recitation periods and one laboratory period each week.

Characteristics and application of direct-current motors, and manual and automatic control equipment, including electrical and mechanical braking. Characteristics and control of induction and single-phase motors. Power factor control for industrial loads; use of fly wheels, hydraulic motor application, hydraulic pumps; drive for machine tools, electric elevators, ventilating fans. Further tests of synchronous generators and motors, synchronous converters, induction and single-phase motors. Professor BURCKMYER, Messrs. ANKRUM and SCHAUSS.

## General Courses

NE1–2. *English.* Required of first- and second-term students in Mechanical and Electrical Engineering. Two terms. Credit three hours a term. The aim of this course is to teach the student to say and write what he means concisely and with a purpose, and to read and listen with precise understanding and discrimination. Problems in oral and written communication; practice in the kinds of expression which students will be called on most often to use—reports of events, summaries of readings and lectures, explanations of problems or situations, letter and report forms, short informal talks, class recitations and discussion. Modern usage—grammar, idiom, sentence structure, punctuation, spelling, organization of material into effective paragraphs and larger units. Readings from periodicals and books, especially of contemporary American writings, to gain information, to extend the student's experience, and to show modern practices in varied types of expression, technical and popular.

Emphasis during the first semester will be on accuracy and conciseness in the handling of informational materials, and during the second semester on judgment and effectiveness in handling materials of considerable complexity and range.

The course will consist of problems in oral and written communication, carried forward coordinately under the following heads:

Writing: Gathering material; planning and writing various kinds of short papers; reporting of observed events; summaries of short passages; letters and reports (including general types of military forms and reports); explanation of problems, situations, and processes of increasing complexity.

Speaking: Clear and full recitations, short informal talks, giving directions, explaining situations and processes (especially those involving diagrams, models, or specimens), taking part in group discussions, and summarizing talks and discussions as a test of listening.

English usage, oral and written: Concise, direct sentences; consecutive and forceful paragraphs; standard practices in pronunciation, punctuation, spelling, idiom, and grammar.

Reading: Varied readings in periodicals and books, to gain information, to extend the student's experience, and to show modern practices in common types of technical and popular expression.

NGE5. *Contracts and Specifications.* Required of sixth-term students in Electrical Engineering, Power Option. Credit two hours. Two lecture-recitation periods each week.

Contract essentials; the discharge of contracts; torts, agency, real property; negotiable instruments; the engineer as an expert witness; employment compensation and accident insurance; contract documents; advertisement, information for bidders, proposals, contract forms, specifications, bonds; engineering ethics and practice. Studies will be made of engineering specifications and practice given in writing such specifications.

NPS1. *Psychology* I—*General.* Required of seventh-term students in Electrical Engineering. Credit three hours. Three lecture-recitation periods each week.

The major objective of this course is to provide an understanding of normal behavior and of leadership. The topics listed below, among others, will be covered: individual differences in behavior areas—general ability, special aptitudes, differential achievement, interest and personality characteristics; bases for individual differences; operational methods in psychology—adjustment factors; measurement and analysis of public opinion and group morale factors; psychological aspects of command, supervision, and administration—training and learning, emotion, rewards and incentives, interviewing for purposes of individual morale, leadership skills. The recitations will aim to give students exercise in applying psychological principles to realistic problems of human relations.

# General Courses of Instruction

Described in this section are certain University courses that fall outside the jurisdiction of any college, courses in the College of Engineering that fall outside the jurisdiction of any one of the four Schools, and courses in the College of Arts and Sciences prescribed for students in engineering. Courses of instruction given by each of the four Schools of the College of Engineering are described under the appropriate heading.

## ENGINEERING

1J31, 1J32. *Engineering Journalism.* Elective for Juniors who are members of the staff of *The Cornell Engineer*. Enrollment for credit must be with the approval of the class adviser. Throughout the year. Credit, two hours. Practical training in magazine editing and business management, including the writing of technical articles, copy reading, proof reading, makeup, and other editorial procedures; also accounting, advertising, the handling of circulation problems, and other phases of business management as related to publishing. Group meetings and individual conferences at hours to be arranged. Associate Professor THATCHER and Mr. SAMPSON.

1J41, 1J42. *Engineering Journalism.* A continuation of 1J31, 1J32. Elective for Seniors who are members of the staff of *The Cornell Engineer*. Enrollment for credit must be with the approval of the class adviser. Throughout the year. Credit, two hours.

## GENERAL UNIVERSITY COURSES

### HYGIENE

1. *Health Problems, Personal and Community.* Two terms. Credit three hours a term. Open to all students, preferably those above the freshman year.

A course designed to give the scientific principles underlying sound personal and community practices.

3. *Health Supervision of School Children.* Two terms. Credit three hours a term. Open to juniors and seniors. Prerequisite, suggested but not demanded, Health Problems, Personal and Community.

A practical course of lectures and demonstrations designed to familiarize the student with the facts and methods necessary for making an effective health supervision of school children.

4. *Advanced First Aid.* Two terms. Credit two hours a term. Enrollment limited, and registration only after conference with the professor in charge.

This course includes the theory of the diagnosis and temporary treatment of the common emergencies with practical application of the essential fundamentals.

8. *Mental Hygiene.* Two terms. Credit three hours a term.

The relationship of the structure of the total personality to environmental maladjustment as evidenced by physical and social behavior; a

discussion of the more common personality difficulties and the role of insight in the prevention of these.

### MILITARY SCIENCE AND TACTICS

1. *Basic Course.* Required. The complete course covers four terms. Three hours a week, either M T W Th or F 1:40–4:10 P.M.

The course of training is that prescribed by the War Department for Senior Division Units of the Reserve Officers Training Corps for basic students. Instruction is offered in Field Artillery and Signal Corps. For details concerning the course see the *Announcement of the Department of Military Science and Tactics.*

Required of all able bodied first and second year male students who are American citizens and candidates for a baccalaureate degree. The requirements of Military Science and Tactics must be completed in the first terms of residence; otherwise the student will not be permitted to register again in the University without the consent of the faculty.

Advanced standing: With the approval of the Department of Military Science and Tactics, credit may be allowed a student for all or part of the Basic Course requirement, upon presentation of evidence of satisfactory work completed at an approved institution.

## ARTS AND SCIENCES

### CHEMISTRY

*Chemistry 1a. General Chemistry* (*Navy Chemistry C1a*). Credit four hours. Lectures, Th S 8 or 9. Main Lecture Room, *Baker* 200. Laboratory, M T W Th or F 1:40–4:30, *Baker* 150. Recitation, one hour to be arranged. Deposit, $13.50.

*Chemistry 2a. General Chemistry* (*Navy Chemistry C2a*). Credit two hours. Prerequisite, Chemistry 1a. Lecture, T 9. Main Lecture Room, *Baker* 200. Laboratory, M T or Th 1:40–4:30 or S 8–11. *Baker* 150. Recitation, one hour to be arranged. Deposit, $13.50. Professor LAUBENGAYER and others.

110 a and b. *Introductory and Inorganic Chemistry.* Credit three hours first term, two hours second term. Prerequisite, entrance credit in chemistry, or course 102.

Required of candidates for the degree of B. Chem. Eng., and recommended for candidates for the degree of A.B. who intend to major in Chemistry.

115. *Introductory Inorganic Chemistry.* Recitations and laboratory practice. Credit three hours. Must be taken with the first term of Chemistry 110. Deposit, $20.

203. *Introductory Qualitative Analysis.* One term. Credit five hours. Prerequisite, Chemistry 115 and Chemistry 110a, or special permission. Deposit, $30. Must be taken with Chemistry 110b. Required of candidates for the degree of B.Chem.Eng. and recommended for candidates for the degree of A.B. who intend to major in Chemistry.

220. *Introductory Quantitative Analysis.* One term. Credit three hours. Prerequisite, Chemistry 203, or 205 and 206, or special permission. Must be taken with Chemistry 221.

A study of the fundamental principles of gravimetric and volumetric analysis with practice in stoichiometry. Students in science and majors in Chemistry are advised to take this course together with Chemistry 221 instead of Chemistry 225.

221. *Introductory Quantitative Analysis.* One term. Credit three hours. Prerequisite, Chemistry 203, or 205 and 206, or special permission. Must be taken with Chemistry 220. Deposit, $25.

Laboratory practice in the preparation and standardization of various volumetric solutions and the analysis of a variety of substances by volumetric and gravimetric methods.

Students in science and majors in Chemistry are advised to take this course together with Chemistry 220 instead of Chemistry 225.

305 a and b. *Introductory Organic Chemistry.* Credit three hours a term. Prerequisite, qualitative analysis. Open to those who are taking Chemistry 220.

Lectures and written reviews. The more important compounds of carbon, their occurrence, methods of preparation, relations, and uses.

Students who have completed Chemistry 375 may register for Chemistry 305b and receive two hours credit.

310 a and b. *Introductory Organic Chemistry.* Credit three hours a term. Prerequisite or parallel course, Chemistry 305. Deposit, $40 a term.

405 a and b. *Introductory Physical Chemistry.* Credit three hours a term. Prerequisite, Chemistry 305 a and b, Mathematics 60a, 60b, 60c, and 60d, and Physics 11 and 12 (or their substantial equivalent). Required of candidates for the degree of B.Chem.Eng.

A systematic presentation of the principles of physical chemistry. The topics include: the properties of gases, liquids and solids; physical and chemical equilibrium in homogeneous and heterogeneous systems; the Mass Law, theorem of Le Chatelier, and the Phase Rule; thermochemistry and elementary thermodynamics; the theory of solutions; ionic equilibria; Chemical Kinetics and catalysis; problems in physical chemistry.

410 a and b. *Introductory Physical Chemistry.* Laboratory and informal recitations. Credit three hours a term. Prerequisite or parallel course, Chemistry 405 or 406. Deposit, $20 a term.

Qualitative and quantitative experiments illustrating the principles of physical chemistry and practice in performing typical physico-chemical measurements. Recitations on the general principles of physical chemistry, based upon the lectures.

420. *Advanced Physical Chemistry.* One term. Credit three hours. Prerequisite, Chemistry 405.

Short course in chemical thermodynamics with applications to thermochemistry and physico-chemical equilibria. Emphasis on the solution of simple problems.

## ECONOMICS

*3. *Introduction to Economics.* For students in Engineering and Chemistry. One term. Credit three hours.

An introduction to the more essential economic features of contemporary American society.

11. *Money, Currency, and Banking.* One term. Credit three hours. Prerequisite, Economics 1 or its equivalent.

An introductory study of the history and theory of money, currency, and bank credit. Enrollment limited.

31. *Corporation Finance.* One term. Credit three hours. Prerequisite, Economics 21a or its equivalent.

A study of the financial practices of business corporations in the United States; types of corporate securities; sources of capital funds; determination and administration of corporate incomes; financial difficulties and corporate reorganizations; the relation of corporate practices to the functioning of the American economic system; and the regulatory activities of the Securities and Exchange Commission.

## ENGLISH

*2. *Introductory Course in Reading and Writing.* Two terms. Credit three hours a term.

The aim of the course is to increase the student's ability to communicate his own thought and to understand the thought of others. The first term will be devoted primarily to the study of good diction, effective sentences, and the logic of paragraphs, the second to whole compositions. Assignment to sections will be made in *Barton Hall* the first term, and in *Goldwin Smith* C the second. Mr. SALE is in charge of the course.

Sections will be arranged for a limited number of students of more than average ability, especially those who expect to major in one of the humanities.

With the written recommendation of his freshman instructor, a freshman may be admitted to English 20 in the second term in place of the second term of English 2. With similar recommendation and the consent of the sophomore instructor concerned, a freshman may elect English 22 or 23 in the second term, in addition to the second term of English 2.

Freshmen who elect Social Science A, B may substitute for English 2 the interdepartmental course, *Oral and Written Expression.*

*2a. *Introductory Course in Composition and Literature.* One term. A repetition of the first term of English 2.

*2b. *Introductory Course in Composition and Literature.* One term. A repetition of the second term of English 2. May be entered by those who have passed the work of the first term.

## GEOLOGY

501. *Engineering Geology.* Required of all sophomores in Civil Engineering. Either term. Credit three hours. The practical application of geologic principles and the occurrence of such economic materials as are of importance to engineering students, the whole subject being treated with reference to their needs. Lectures and laboratory work. Fee, $4.50. *McGraw Hall.* Professor NEVIN.

## MATHEMATICS

*60a, *60b, *60c, 60d. *Analytic Geometry and Calculus.* Credit three hours for each course. Primarily for students in the College of Engineering.

## PHYSICS

*11. *Introductory Experimental Physics.* One term. Credit four hours. Prerequisite, Calculus or simultaneous registration in Mathematics 55a, 60a, or 65b. Entrance physics desirable but not required. Two lectures, two recitations, and one laboratory period a week. Laboratory fee, $5.

Demonstrations, theory, problems, and experiments covering subjects of mechanics, wave motion, sound, and heat.

Required of candidates for the degrees of B.C.E., B.Chem.E., B.E.E., and B.M.E. and B.S. in A.E.

*12. *Introductory Experimental Physics.* One term. Credit four hours. Prerequisite, Calculus or simultaneous registration in Mathematics 55a, 60a, or 65b. Entrance physics desirable but not required. Two lectures, two recitations, and one laboratory period a week. Laboratory fee, $5.

Demonstrations, theory, problems, and experiments covering the subjects of electricity, magnetism, and light.

Required of candidates for the degrees of B.C.E., B.Chem.E., B.E.E., B.M.E., and B.S. in A.E.

21. *General Physics.* One term. Credit three hours. Prerequisites, Physics 11, 12 and differential and integral calculus. Two recitation periods a week and one laboratory period in alternate weeks. Laboratory fee, $2.50.

Required of candidates for degrees of B.Chem.E., B.E.E., and B.M.E.

A study of the fundamental laws of electric and magnetic fields and their applications to elementary circuit phenomena. Topics covered: the electrostatic field; potential; Gauss's Law; study of direct current circuits; Kirchhoff's rules; the magnetic field of steady currents; induced e.m.fs.; inductance; capacitance; simple transients. The laboratory work deals with the fundamentals of electrical measurements in direct current circuits.

22. *General Physics.* One term. Credit three hours. Prerequisites; Physics 11, 12, differential and integral calculus. Two recitation periods a week and one laboratory period in alternate weeks. Laboratory fee, $2.50.

Required of candidates for degrees of B.Chem.E., B.E.E., and B.M.E.

Selected topics in thermionics, photoelectricity; elementary geometrical optics; physical optics; heat radiation; simple spectra. The laboratory work covers certain phases of electronics such as, the measurement of work function, study of gas filled photocell; characteristic curves of the magnetron. Other experimental work deals with photometric measurements, resolving power; polarization of light.

## PUBLIC SPEAKING

*1. *Public Speaking.* One term. Credit three hours. Not open to freshmen.

Planned to give the fundamentals of speech preparation and to develop simple and direct speaking. Study of principles; constant practice; conferences.

Foreign students and others whose pronunciation of English falls below the normal standard, and students with special vocal problems, are advised to confer with Mr. THOMAS before registering.

# Index